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Investigating Commodity Price Relations across Wholesale Markets: The Case of Paddy in Chhattisgarh, India

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ABSTRACT

Integration among domestic markets is a necessary condition for economic efficiency and it ensures maximum gains for all agents in the marketing chain (producers, consumers, and intermediaries). This paper uses an Autoregressive Distributed Lag (ARDL) model to test for market integration across wholesale markets of paddy in Chhattisgarh - a state in eastern India where a large share of the population is engaged in paddy cultivation. Using monthly data from 2004 to 2016, the study does find evidence of significant horizontal price transmissions among markets both within and across different districts of the state. However, the speed of price adjustments to long-run equilibrium is found to be slow. This indicates that market integration within the state is, at most, weak and, therefore, it is not advisable to excessively rely on price-support policies without initiating market reforms for improved integration. Interestingly, the findings about price transmission (and market integration) are found to be sensitive to the choice of paddy variety: different varieties sold in the same *mandi* show no evidence of interdependence. Finally, the study identifies lead, lag and isolated markets within the state. Given the imperfections and inequities that exist in the implementation of agricultural price policies (especially in terms of access to support prices) across India, these findings can act as crucial inputs for reassessing policy interventions.

Keywords: Agricultural price, Market integration, Wholesale markets, Paddy, Price shocks.

JEL: Q02, Q11, Q13, Q18.

I

INTRODUCTION

The study of linkages in price movements across spatially separated markets falls within the broad literature of 'market integration'. While market integration is not a sufficient condition for Pareto optimality (Newbery and Stiglitz, 1984; Ravallion, 1986), it is still a necessary condition (Ravallion, 1986). In integrated markets, prices get determined interdependently. This transmission of price signals and information across markets can ensure efficient resource allocation and more stable prices (Acharya, 2001; Tankari and Goundan, 2018). Gains from liberalisation and globalisation are contingent on the presence of an efficient market network of agricultural commodities (Timmer, 1989; Jayasuriya *et al*., 2008).Most importantly, unless agricultural markets are integrated at the national (or state) level, a blanket agricultural policy at the national (or even the state) level would be unsuitable (Jha *et al*., 2005).

In recent decades, the Government of India has often relied on price-policy measures (like raising the minimum support price) as a tool to mitigate farmer

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distress. However, the access to measures like minimum support prices (MSP) is uneven across the country. For instance, farmers in several markets are either unaware of MSP or they are not able to opt for MSP (even when prices crash) due to operational reasons (NSSO, 2014; Bathla, 2012; Chatterjee, 2019). Now, the law of one price (LOP) will operate only if price signals are transmitted across these spatially separated markets. Otherwise, there will be a sustained gap between markets with and without access to price support-measures, with the sellers in the latter group being left out of policy reach.

Ravallion (1986) argues that an empirical measure of market integration provides basic data for understanding how specific markets work. In developing countries, where most farmers are resource-poor smallholders, estimating the extent of market integration can guide price-instrument-based policies and market-based reforms to improve the performance of local markets. While inter-state barriers in grain trade may be a cause of low market integration nationally, the absence of transmissions within any state would imply other reasons for non-transmission. With the government focusing on improved information flow through portals like e-NAM,[1] the cost of information is expected to fall, thus resulting in greater market-integration. Further, the much-debated Farm Bills of 2020 indicated an apparent shift in policy towards market-based reforms by allowing a freer role and increasing private-sector participation in foodgrain trade. These developments make it all the more relevant to assess market integration at the national, regional and state level.

This paper takes up the case of price transmissions across wholesale markets in the eastern Indian state of Chhattisgarh, where a large section of cultivators comprises small holders. The crop studied is 'paddy', the state's most widely cultivated commodity accounting for 66 per cent of cropped area.[2] The state produces over 19 thousand rice varieties, has been conferred the "Krishi Karman Award" four times by the Government of India in recognition of its meritorious efforts in rice production, and is known as "Rice Bowl of India". Despite the state's performance in terms of agricultural production, reports of farmer distress have been recurring from the state with a large number of suicides being committed by farmers (Manjunatha and Ramappa, 2017). The National Crime Records Bureau (NCRB) of India places Chhattisgarh among five states that account for 90 per cent of the total farmer suicides reported across the country. Most of the state's population (77 per cent) depend on agriculture for their livelihood (Census of India, 2011) and a majority of its farmers (over 82 per cent) belong to the 'small and marginal' category (Government of India, 2019) who earn very low-incomes (NSSO, 2014; Birthal *et al*, 2017). The state also has a disturbingly high poverty rate, with 40 per cent of its population living below the poverty line (NSSO, 2014). As paddy is the state's main crop in terms of area and volume, returns from paddy cultivation affect the livelihood sustainability of most of Chhattisgarh's farmers. If price-signal transmissions across markets are weak, price support policies alone would not address concerns like nonremunerative prices, price crashes due to bumper harvest or price spikes due to localised monsoon failure.

Integrated markets have high potential to mitigate adverse effects of supply shocks (Sekhar, 2012). By the same token, absence of integration can lead to persistence of local food scarcities as markets with surplus supply will not respond to price signals from supply-deficit markets (Dreze and Sen, 1995; Currey and Hugo, 1984). When price transmissions are imperfect or asymmetric, large gaps in price difference may persist and the consequent volatility may be passed on to the producers and consumers (Bathla and Srinivasulu, 2011).

Thus, an examination of market integration is important from policy perspective. In case markets are fragmented or isolated, it is advisable for the government to instead focus on policy variables that strengthen market infrastructure, improve information dissemination, reduce transaction costs and so on (Acharya, 2001; Bathla and Srinivasulu, 2011). In developing countries, agricultural markets usually show less integration due to high transaction costs (transport, margins, risk premiums, cost of information and so on). In India, integration may be further hindered by continued government interventions in grain markets, occasional policy barriers on inter-state foodgrain movement, and regional biases in price and procurement policy (Jha *et al.*, 2005; Bathla and Srinivasulu, 2011; Mittal *et al.*, 2018). Interestingly, Conforti (2004) reports that annual domestic prices of some major agricultural commodities (including rice) show considerable linkage with world reference prices in countries like India, Pakistan, Egypt and Indonesia, notwithstanding the overall policy attitude of high public regulation for long periods. His work, however, uses all-India prices that, he remarks, are not representative of a vast and diverse country like India. Jayasuriya *et al.* (2008) find that the integration of domestic market of rice with international market improved significantly after the liberalisation. However, Mittal *et al*. (2018), who conduct a disaggregated study on rice and wheat prices in India, conclude that volatility in domestic prices is more influenced by internal production shocks than international prices. Studies that focus on transmissions across domestic markets in India do find evidence of improved market integration after the neo-liberal reforms of 1990s, but the nature of this integration is reported to be far from perfect (Jha *et al*., 1997; Wilson, 2003; Acharya, 2001; Jha *et al.*, 2005; Kumar, 2007; Bathla, 2011; Sekhar, 2012; Paul and Singha, 2015; Paul *et al.*, 2016). If we focus on rice/paddy, the evidence has mostly been that of weak integration. Jha *et al.* (2005)'s study monthly rice prices in 55 wholesale markets across India (1970 to 1999) report market integration to be incomplete. Sekhar (2012) also finds that rice markets (compared to other crops) show a lower extent of integration and exhibit relatively longer speed of adjustment.

Most of the works cited here use averaged prices to study market integration, which does not reflect intra-state differences. Sekhar (2012) specifically shows that markets in the eastern region of India show lower integration, particularly in the case of rice. Hence, in this paper, an attempt has been made to take up the case of paddy within one such state from eastern India.

The null hypothesis being tested is that there is no market integration. Based on its findings, the paper separates *mandis* that do not show evidence of spatial transmissions across them from those that do (if any). This helps us identify ‘isolated’ markets, which may need targeted policy interventions.

The rest of the paper is organised as follows. Section II presents the methodological framework and discusses the data. Section III presents the empirical findings on the nature of integration across *mandis* of Chhattisgarh. Section IV concludes.

II

METHODOLOGICAL FRAMEWORK AND DATA

2.1 *Data: Sources, Specification and Transformation*

The study examines the degree of integration (interdependence) among wholesale markets (*mandis*) of paddy in Chhattisgarh. The period of reference is from 2004-05 to 2016, the choice of which is guided by a number of considerations. First, sufficient time is allowed for lagged effects of policy changes that occurred during the nineties in India to phase in: the New Economic Policy, opening up of the agricultural sector to the rest of the world (Agreement on Agriculture under WTO[3]), and the subsidy and credit cuts to agriculture. The period from about 2005-06 also marks a new phase of increased irregularity in movements of both domestic and world commodity prices (Bathla, 2012; Tripathi, 2014; Ott, 2012; Baffes and Haniotis, 2016; Harvey *et al*, 2017). This gives further validation to the choice of the period. The year 2016 is taken as the cut-off year because of two reasons: (i) two major policy reforms viz., demonetisation (November, 2016) and the Goods and Services Tax (GST) regime (July, 2017) were initiated in quick succession around this period, which adversely affected the agricultural sector, at least in the short-run, due to severe cash constraints and administrative hindrances (Govindasami, 2017; Goel, 2018; Browske, 2019; Baig, 2019; Chodorow-Reich *et al*., 2020; Lahiri, 2020); (ii) the years from 2015 have seen back-to-back droughts in India (Government of India, 2018; Todmal, 2019; Global Drought Observatory, 2019) severely affecting India’s largely rain-fed agricultural production (Government of India, 2016) and therefore, prices.

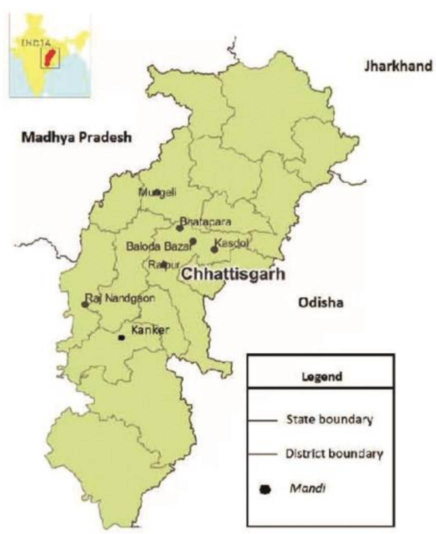
Data on paddy price is analysed for Chhattisgarh’s primary wholesale markets (*mandis*), where the first sale of primary agricultural produce is mandated by the state Agricultural Produce Market Committee (APMC) Acts.[4] Daily prices reported at wholesale *mandis* are available from Directorate of Marketing and Inspection (DMI), Government of India (GoI) (http://agmarknet.gov.in).[5] From each market-level price series, monthly average of the daily modal price is calculated.[6] Using nominal price data (unadjusted for inflation) may lead to bias arising from common inflationary trends. Each series is deflated by the respective month's WPI for rice to obtain the real (constant 2004-05) price. These prices are then transformed to their natural logarithms to ensure that all series are normally distributed to facilitate parametric testing.

Table 1 provides details about the price-series included in the analysis and Figure 1 presents the location of included *mandi*s on a representative district map. Chhattisgarh has three diverse agro-climatic zones. Among these, paddy cultivation is most intensive in the Central Plains where 35 per cent of the state's irrigated area is concentrated (NSSO, 2014). As most of the state's paddy is sold in markets of this region, they have relatively higher representation in the set of *mandis* included in this study.

TABLE 1. LIST OF PRICE SERIES FROM *MANDIS* of CHHATTISGARH INCLUDED IN THE ANALYSIS

Sl no (1)	Mandi (2)	District (3)	Variety of Paddy* (4)
1.	Raipur#	Raipur	Other/Paddy
2.	Bhatapara#	Raipur[a]	Paddy Fine
3.	Bhatapara#	Raipur[a]	Paddy
4.	Balodabazar	Raipur[a]	Paddy Fine
5.	Kasdol	Raipur[a]	Paddy
6.	Rajnandgaon#	Rajnandgaon	Other
7.	Rajnandgaon#	Rajnandgaon	Paddy Medium
8.	Mungeli#	Bilaspur	Paddy Fine
9.	Charama	Kanker/North Bastar	Other

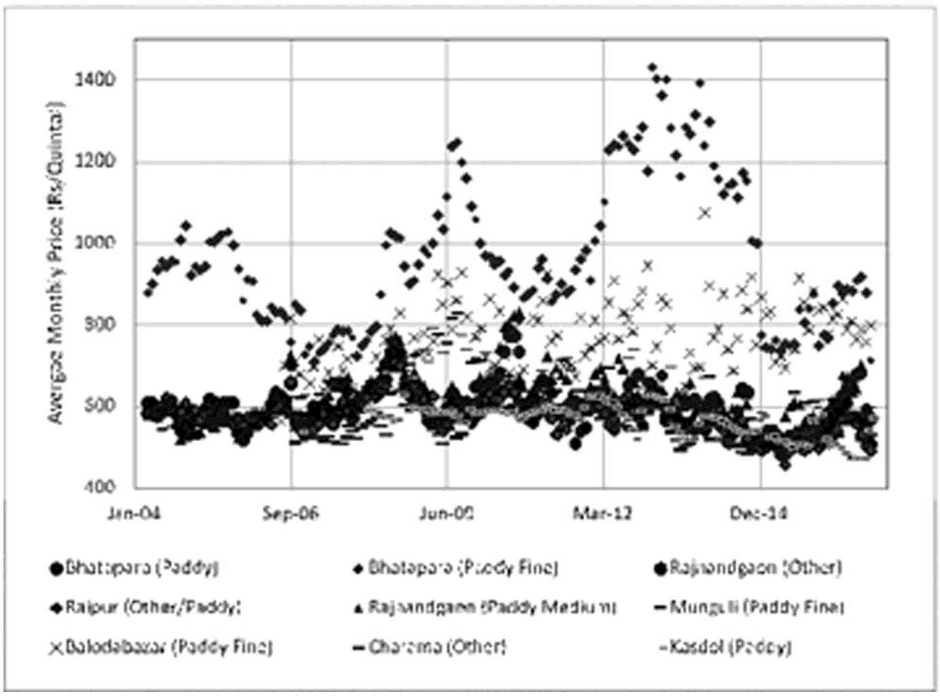
Note: *The 'variety' reported here is as it is listed in the dataset obtained from the Directorate of Marketing and Inspection (DMI), Government of India (GoI) (http://agmarknet.gov.in)# These are among the 14 *mandis* from Chhattisgarh that are covered under eNAM. [a] In 2012, the Balodabazar-Bhatapara district was carved out of Raipur and these *mandis* now fall under the former's jurisdiction.



Source: Generated by author using QGIS software.
Note: Map not to scale.

Figure 1. Map of Chhattisgarh: *Mandis* under Study

Next, Figure 2 presents the time-series plots of each *mandi* level price series. Except for the 'paddy fine' variety, all the other series tend to cluster together. Their movements over time also appear to be approximately similar. Further econometric testing will provide clearer evidence on these linkages.



Source: Author's calculations using data from the DMI, GoI.

Figure 2. Plots of the Monthly Average Price of Paddy Varieties from the Selected *Mandis* of Chhattisgarh from 2004 to 2016.

2.2 *Modelling the Series*

First, the time-series properties of each series are examined to determine whether they are trend stationary or difference stationary. For this, the paper uses the Dickey-Fuller-GLS (DF-GLS) unit root test proposed by Elliott *et al.* (1996), which has significantly greater power compared to previous versions of the augmented DF test.[7]

The stationarity tests (results in Table 2 of Section 3.1) indicate the series under study to be of mixed type, i.e., some are stationary at level and others are non-stationary. Differencing, de-trending or filtering to make all variables stationary often leads to the loss of long-run relationship/information. Instead, this paper uses the Autoregressive Distributed Lag Model (ARDL) cointegration technique, which can determine the long run relationship between series having different orders of integration (Pesaran and Shin, 1999, and Pesaran *et al*. 2001). This approach is effective in small samples and, if augmented sufficiently, it avoids uncertainty about variable exogeneity. It also enables estimation of economic relationships in levels. As price adjustments to shocks are generally sluggish and involve considerable time lags, the short-run and the long-run behaviour of a market integration process can differ (Ravallion, 1986). The ARDL model can estimate both the long-run (equilibrium) and the short-run (dynamic) relationships among variables (Pesaran *et al.*, 2001). These advantages make the model an ideal choice. It can also be reparametrised into an empirical error correction model (ECM), which brings together the short-run dynamics and long run relationship of the considered variables.

The specification of the ARDL also needs to account for seasonality as monthly data on agricultural commodity prices often display a strong seasonal component. The source of seasonality is the seasonal nature of the harvest, resulting in prices dropping substantially in the harvest month due to excess supply. However, the exact nature of market arrivals would depend on trading and storage strategies adopted by farmer-sellers. Further, given the rise in 'summer paddy' cultivation in Chhattisgarh,[8] the harvest month itself may be difficult to define for each variety. Therefore, it makes sense to allow the data to decide the seasonal structure. To account for seasonality, recent studies either use a ratio-to-moving-average method (Bathla and Srinivasulu, 2011) or incorporate monthly seasonal dummies (Sekhar, 2012; Gilbert *et al*, 2017) to account for seasonality. Here, we include eleven seasonal dummies ($D_1, \ldots D_{11}$) in the ARDL specification, with the twelfth month serving as the base.

The general form of the ARDL$(p,q_1,\ldots,q_k)$ model for a particular dependent price series (y) with respect to a vector of all other prices series ($\boldsymbol{X}i$) can be expressed as:

$$\Phi(L,p)yt = \beta_0 + \sum_{i=1}^{k} \beta_i(L, q_i)x_{it} + \delta St + ut \qquad \text{….(1)}$$

for i=1,2,3…….k, ut ~ iid(0;δ2).

Here,

$\Phi(L, p) = 1 - \Phi 1L - \Phi 2L^2 \ldots - \Phi pL^p$

$\beta(L, q) = 1 - \beta 1L - \beta 2L^2 \ldots - \beta qL^q$

L is a lag operator and *St* is an *11 x1* vector of seasonal dummies (*i.e.* the exogenous variables in the model having fixed lags). The optimal lag length for endogenous variables is determined using the Schwarz-Bayesian (SIC) criterion, which provides slightly better estimates than the AIC criteria in small samples in the ARDL framework (Pesaran and Shin, 1999). Finally, post-estimation tests are conducted for residual serial correlation, residual normality and model specification. The stability of the long-run and short-run coefficients of each ARDL model is the cumulative sum (CUSUM) and moving sum (MOSUM) of recursive squares tests proposed by Brown *et al*. (1975) and Chu *et al.* (1995). The ARDL specifications are altered if and when any post-estimation statistic indicates a problematic fit.

All estimations are conducted using R. The ARDL estimation uses the package developed by Natsiopoulos and Tzeremes (2021).

III

ARE PADDY PRICES INTEGRATED ACROSS CHHATTISGARH'S *MANDIS*?

This section presents the findings regarding market integration for paddy within the state of Chhattisgarh. As mentioned in Section II, all econometric analyses are conducted on log-transformed monthly averages of daily modal (constant 2004-05) price.

3.1 *Time-Series Properties of the Price Series*

The results of the Dickey-Fuller-GLS (DF-GLS) test for presence of unit root are presented in Table 2. At five per cent level of significance, the null of the presence of a unit root can be rejected only in the case of Bhatapara *mandi* (Paddy) and Balodabazar *mandi* (Paddy fine). Thus, the first general inference is that, in most cases, price shocks(and crashes) have a lasting effect on the level of prices in the future. Then we proceed to formal testing for price signal transmissions.

TABLE 2. TIME-SERIES PROPERTIES OF LOG PRICE SERIES

Price series (1)	GF-GLS tau test statistic (2)	Optimal lag length (3)	Conclusion (4)
Raipur (Other)	-1.824	10	I(1)
Bhatapara (Paddy Fine)	-2.574	12	I(1)
Bhatapara (Paddy)	-3.12	7	I(0)
Balodabazar (Paddy fine)	-3.289	6	I(0)
Kasdol (Paddy)	-0.945	12	I(1)
Rajnandgaon (Other)	-2.39	12	I(1)
Rajnandgaon (Paddy Medium)	-1.86	12	I(1)
Mungeli (Pady Fine)	-1.787	11	I(1)
Charama (Other)	-2.297	7	I(1)

Source: Author's calculation.
Note: The optimal lag length is selected based on the Ng-Perron sequential t-test.

3.2 *Modelling Horizontal Price Transmissions*

Each price series is modelled on all the other price series using an ARDL-cointegration framework. The procedure involves two stages. The first step is estimation of an ECM from Equation (1) and testing the joint significance of the coefficients of the lagged level regressors (based on F-statistic) using critical values developed by Pesaran *et al*. (2001). Suppose the F-statistic lies above the upper bound critical value for a given significance level. In that case, a non-spurious long-run level relationship can be inferred between the regressors and the dependent variable. The second step is undertaken only when the F-statistic is significant. It involves estimation of an underlying ARDL model, estimation of the long-run (equilibrium) coefficients between levels and estimation of the ECM that underlies the ARDL model.

The results of the first stage of the ARDL-cointegration procedure are summarised in Table 3 along with some important post-estimation test-statistics. The plots for the respective CUSUM and MOSUM tests are presented in Figure 3.

TABLE 3. ARDL BOUNDS TEST AND MODEL DIAGNOSTICS

District	Raipur	Raipur	Raipur	Raipur	Raipur	Rajnandgaon	Rajnandgaon	Bilaspur	Kanker
Market (variety)	Raipur (Other)	Bhatapara (Paddy Fine)	Bhatapara (Paddy)	Balodabazar (Paddy fine)	Kasdol (Paddy)	Rajnandgaon (Other)	Rajnandgaon (Paddy Medium)	Munguli (Pady Fine)	Charama (Other)
Optimal lag structure	(1,1,1,1,1,1,1,1,1)	(1,1,1,1,1,1,1,1,1)	(1,1,1,1,1,1,1,1,1)	(1,1,1,1,1,1,1,1,1)	(2,1,1,1,1,1,1,1,1)	(1,0,0,0,0,0,0,0,0)	(1,1,1,1,1,1,1,1,1)	(1,1,1,1,1,1,1,1,1)	(1,1,1,1,1,1,1,1,1)
Bounds F-test (Wald) for no cointegration									
F	3.775 *	1.084	4.862 **	4.835 **	2.439	16.265 ***	3.436 *	2.982	2.422
Breusch-Godfrey Test for the autocorrelation in residuals									
LM test	0.039	0.755	0.142	2.703	0.048	37.454	0.298	4.411	0.367
df	1	1	1	1	1	1	1	1	1
p	0.844	0.385	0.707	0.100	0.826	0.000	0.585	0.036	0.544
Ljung-Box Test for the autocorrelation in residuals									
Chi-squared	0.016	0.537	0.049	0.912	0.005	24.209	0.122	1.849	0.188
df	1	1	1	1	1	1	1	1	1
p	0.899	0.464	0.825	0.340	0.945	0.000	0.727	0.174	0.665
Shapiro-Wilk normality test									
W	0.989	0.983	0.990	0.987	0.941	0.987	0.989	0.984	0.970
p	0.315	0.056	0.365	0.157	0.000	0.188	0.308	0.075	0.002
Ramsey's RESET Test for model specification									
RESET	0.269	2.950	0.170	2.187	2.047	1.730	0.577	1.692	2.049
df	2 and 121	2 and 121	2 and 121	2 and 121	2 and 119	2 and 140	2 and 121	2 and 121	2 and 121
p	0.764	0.056	0.844	0.117	0.134	0.181	0.563	0.189	0.133

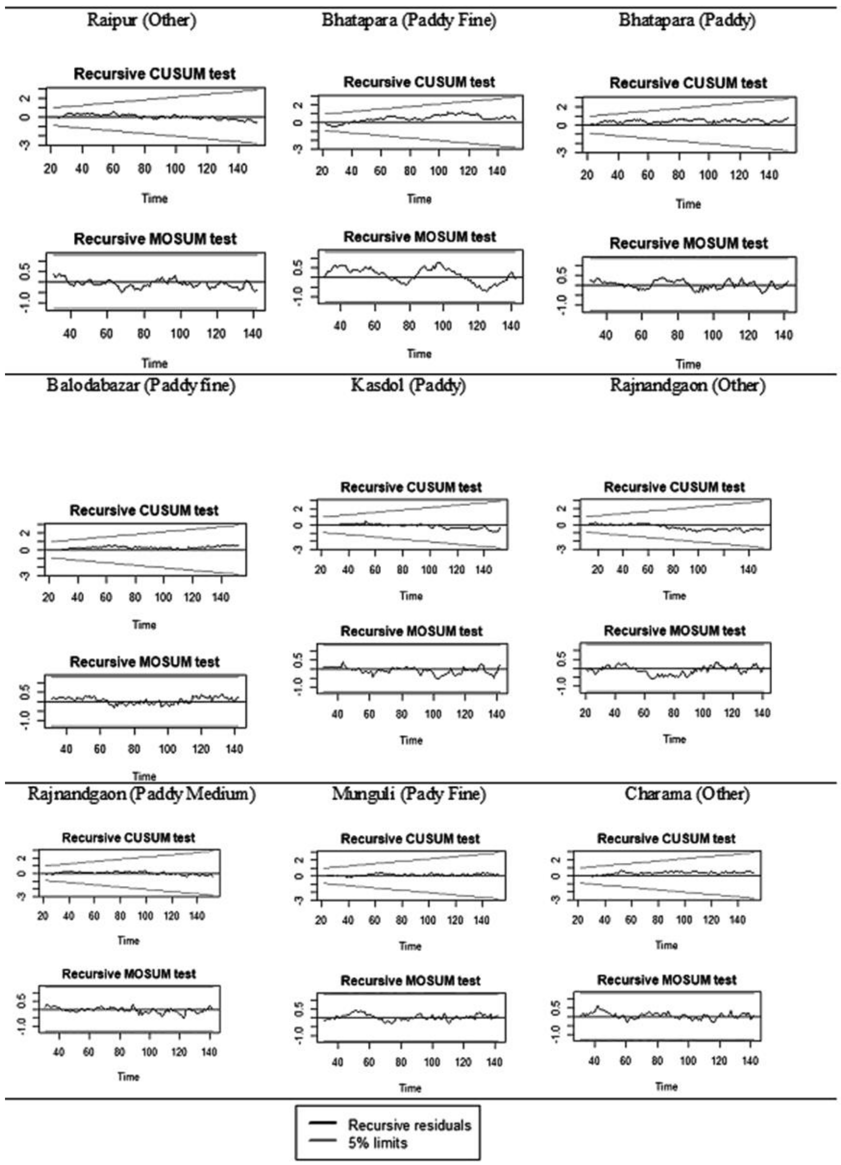
Source: Author's calculations.

Note: Sig. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; D1,..D11 represent the (monthly) seasonal dummies with D1 corresponding to January and so forth upto D11 (November).

At 5 per cent level of significance, the Bounds F-test indicates presence of at least one co-integrating vector in five out of nine cases under study. Thus, while there is some evidence in favour of horizontal price signal transmissions, we cannot conclude that there is complete market integration for paddy within the state.

The price-series that show no evidence of transmission from other markets are Bhatapara (paddy fine) and Kasdol (paddy) in Raipur district, Mungeli (paddy fine) in Bilaspur district and Charama(other) in Kanker (North Bastar) district. Another case in point is the price series for the variety 'other' in Rajnandgaon where the optimal lag structure (suggested by the information criteria) does not include any lags of the other price series. Even the model statistics indicate a misfit if lags of other markets are included in the specification.

A better understanding of the long-run and short run dynamics can be obtained from the coefficient estimates presented in Table 4. Here the coefficients for the seasonal dummies are also included (D1,…D11). Results are only presented for the price-series that show significant evidence against the null hypothesis of no cointegration in stage 1.



Source: Author's calculations

Figure 3. ARDL Model Stability Diagnostics.

The ARDL estimates (Table 4) show that the equilibrium relationships and coefficients estimated display satisfactory diagnostic statistics. The results indicate significant inter-district price signal transmissions: all the included price-series show some influence on at least one other market. Based on the coefficient estimates, the markets under study can be categorized in terms of their *lead-lag* influences. A *lead* market is one from which shocks are transmitted to other markets, and a *lag* market is one which gets affected by shocks in some other market(s). Among the markets studied, four show no evidence of being influenced by price movements in other markets (Bhatapara (paddy fine), Kasdol (paddy), Mungeli (paddy fine) and Charama (other)). These markets can be interpreted as pure *'lead'* markets among the set of markets considered in this study. Further, among all 'lead markets', it is the two paddy varieties from Rajnandgaon *mandi* that have the most number of significant influences on prices of other *mandis*. (esp. Raipur).

TABLE 4. ESTIMATES OF THE UNDERLYING LONG-RUN RELATIONSHIPS

District	Raipur		Raipur		Raipur		Rajnandgaon	
Market (variety)	Raipur (Other)		Bhatapara (Paddy)		Balodabazar (Paddy fine)		Rajnandgaon (Paddy Medium)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ECT (t-1)	-0.394	***	-0.482	***	-0.488	***	-0.396	***
Raipur (Other)			0.451	***	0.125		0.084	
Bhatapara (Paddy Fine)	0.072	*	-0.007		-0.008		-0.024	
Bhatapara (Paddy)	0.304	***			-0.396	.	0.511	***
Balodabazar (Paddy fine)	0.009		-0.044	.			0.056	*
Kasdol (Paddy)	-0.033		-0.011		0.277	**	0.086	
Rajnandgaon (Other)	0.288	***	-0.179	*	-0.075		0.554	***
Rajnandgaon (Paddy Medium)	0.056		0.503	***	0.493	*		
Munguli (Paddy Fine)	0.005		0.046		0.273	**	-0.032	
Charama (Other)	0.082		0.148	*	0.171		-0.058	
D1	-0.021	*	0.020		0.109		-0.003	
D2	-0.024	*	0.016		0.047		0.008	
D3	-0.022	*	0.016		0.026	**	0.007	
D4	-0.023	*	0.026	*	0.118		0.003	
D5	-0.027	**	-0.007		0.028		0.012	
D6	-0.049	***	-0.007		0.044		0.057	***
D7	-0.012		-0.016		-0.062		0.046	**
D8	-0.018	.	-0.013		-0.018		0.038	**
D9	-0.027	*	0.010		0.067	.	0.025	.
D10	-0.031	**	-0.002		0.022		0.040	**
D11	0.015		-0.018		0.002		-0.013	
Intercept	-0.367	***	0.883	***	3.343	***	-0.757	***
Residual standard error	0.023		0.029		0.086		0.029	
df	131		131		131		131	
Multiple R-squared:	0.665		0.727		0.473		0.805	
Adjusted R-squared:	0.614		0.686		0.392		0.775	
F-statistic:	13.01		17.47		5.87		27.05	
df	(20, 131)		(20, 131)		(20, 131)		(20, 131)	
p-value	0.00000		0.00000		0.00000		0.00000	

Source: Author's calculations.
Note: Sig. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

With Raipur being the capital of Chhattisgarh, the results could indicate that there is relatively better information flow to the *mandi*s of the district (even if not vice versa). Among the 'lag' markets, most *mandi*s from Raipur show evidence of being influenced by price movement in a number of other *mandi*s from both within and outside the district. Further, almost all the *mandis* covered under eNAM (except for Mungeli) show evidence market integration of varying degrees. This indicates a positive influence of the e-trading portal in strengthening information flow across *mandis*.

While geographical proximity does seem to favour the strength of transmissions, the presence of inter-district linkages indicates that this is not a necessary condition. By contrast, differences in the variety of paddy chosen from a market shows different results. In both Rajnandgaon *mandi* and Bhatapara *mandi*, the two respective paddy varieties show no evidence of interdependent price formation. Thus, conclusions about market integration may be highly sensitive to the choice of variety of the same crop.

The error correction term (ECTt-1) is negative and statistically significant at less than 1 per cent level for all the markets that show integration. This means that any disequilibria in price formations get adjusted in the long-run. However, the ECM coefficient is low in magnitude, which indicates slower speed of adjustment. This finding is in line with those of Jha *et al*. (2005), Bathla (2009) and Sekhar (2012) for rice markets in India. Sekhar (2012) specifically finds the speed of price convergence to be lowest in the eastern region of India compared to the rest of the country. Jha et al. (2005) attributes the fragmentation in wholesale rice markets largely to excessive state interference in rice markets, which reduces market efficiency by making it hard for supply-abundant markets to pick up signals about scarcity in isolated markets. Bathla and Srinivasulu (2011) add that, in the short-run, factors like monopolistic behaviour of traders and increase in profit margins, high storage, transaction and inventory holding costs can also prevent commodity prices from integrating across domestic markets of India.

IV

CONCLUSIONS

This study investigates price linkages across *mandis* of Chhattisgarh for the state's most widely cultivated commodity - paddy. While low market integration in India is often attributed to inter-state barriers in grain trade, absence of transmissions within markets of a state would imply other reasons for non-transmission. The empirical investigations for inter-*mandi* price interdependence does find statistically significant evidence to reject the null-hypothesis of no market integration. However, the estimates indicate slow and weak price signal transmissions. Thus, there is not enough evidence to suggest perfect integration. Some *mandis* act as 'lead markets' in the state: any change in price in these *mandis* affects paddy prices in many other *mandis*. Such transmissions are not restricted to markets within a single district. The study also identifies *mandis* showing no evidence of being affected by price changes in other markets (among those included in the study). These *mandis*, however, cannot be termed as 'isolated' because all of them show some evidence of affecting price formation in at least one other *mandi*. An interesting finding is that estimates of price transmission (and market integration) are sensitive to the choice of paddy variety, i.e. different varieties sold in the same mandi do not show evidence of price-interdependence. Therefore, market integration studies conducted in the future should explicitly consider variety differences.

The study finds that the speed of price adjustments to a long-run equilibrium is slow and price shocks tend to persist in markets. This indicates that supply-surplus markets may take a long time to respond to any supply deficit in other markets within the state. As studies like Jha *et al.* (2005) and Sekhar (2012) also find the same to be true during the decades preceding the period of reference of this study, we infer that market integration for rice in eastern state of India has not improved in the subsequent years. Furthermore, since the study investigates intra-state transmissions only, the weak integration cannot be attributed to intra-state policy barriers on grain trade. Thus, I concur with recommendations of eminent works like Acharya (2001) and Bathla and Srinivasulu (2011) that the government must focus on policy variables that strengthen market infrastructure, improve information dissemination, reduce transaction costs and so on. A point to note is that all *mandis* covered under eNAM show evidence of relatively better price-linkages. Thus, increasing coverage of eNAM and encouraging farmer participation could be show significant improvement in market-integration.

The findings also provide important insights relevant for India's support price policy. An issue with the Minimum Support Price (MSP) policy is that several farmers are either unaware of it or do not have state procurement agencies in their region (NSSO, 2014). Even in several regulated *mandis*, farmers often receive a price lower than the declared MSP (Bathla, 2012; Chatterjee, 2019). Now, in Chhattisgarh, most sellers are small and marginal farmers (SMF). For instance, the proportion of SMF is over 80 per cent in both Raipur and Bilaspur, and over 70 per cent in Rajnandgaon.[9] These farmers may not be in a position to bear repeated price crashes financially. Thus, at times when returns from agriculture are not remunerative for many (Government of India, 2006; NSSO, 2014; Birthal *et al.*,2017), monitoring prices of the lead markets would enable anticipation and mitigation of price shocks in lag markets. Again, lead markets can form a manageable set of locations to target policy instruments for effective implementation. Given the existing inequity in procurement (NSSO, 2014), the benefits of a raised MSP may not percolate to all the locations unless there is a fair degree of market integration. However, if procurement is, at least, ensured in major locations where important lead markets are located, some benefits of price support may reach other markets that are currently left out. This proposition of course needs to be formally tested and can be taken up in future research. At the same time, in markets which are not impacted by dynamics of other markets, any policy support/intervention has to be direct and specific. Taking the same example, the benefits of price support measures would not percolate to the pure lead markets identified here unless procurement takes place in those regions. As India is a vast country, we need more research at disaggregated levels to get a clearer picture of ground realities.

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NOTES

1) National Agriculture Market (eNAM) is a pan-India electronic trading portal which networks existing APMC mandis to create a unified national market for agricultural commodities.

2) Directorate of Economics and Statistics, Dept. of Agriculture, Co-operation and Farmer Welfare, Government of India.

3) Further, WTO allowed developing countries like India a *transition period* of five years (i.e., upto 2000), for implementing most of the provisions.

4) With time, the APMC markets have largely been rendered restrictive and monopsonistic (Government of India, 2017). Therefore, the APMC Acts were replaced by the Agricultural Produce and Livestock Marketing (Promotion and Facilitation) Act, 2017, which sought to make agricultural marketing more competitive across the country. More recently, in 2020, three new Farm Bills have been passed, which seek to change the nature of agricultural marketing in India.

5) All the markets covered in the dataset cannot be included in the analysis as there are large data gaps in most cases. Therefore, a sub set of markets is selected based on the availability of sufficiently continuous price series (gaps less than 25-30 per cent in the period of study).

6) In the data source, prices are quoted in terms of the maximum, minimum and modal price per day.

7) The DF-GLS test is an augmented Dickey–Fuller test, where the time series are transformed via a generalised least squares (GLS) regression before performing the test. If a series is trend stationary i.e. I(0), shocks in the series do not have a lasting effect and they disappear over time. If the order of integration is a fraction ($d < 1$), the series tends to have a long memory of the any shock. If a series is difference stationary I(1), then shocks are persistent and they do not disappear over time.

8) Data from Commissioner Land Records for Chhattisgarh show that the sowing area for *Rabi* paddy reached 1,90,000 Ha by 2016 (http://agriportal.cg.nic.in).

9) These figures are taken from Agricultural Census 2010-11 published by the Government of India on the Agricultural Census Portal (http ://agcensus:nic:in)

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