How effective is e-NAM in integrating food commodity prices in India? Evidence from Onion Market

No. 336
07-April-2021
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How effective is e-NAM in integrating food commodity prices in India? Evidence from Onion Market

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Abstract

A series of market distortionary rules and regulations hinder development of an integrated agricultural market in India. In order to ensure greater transparency and uniformity of food commodity prices across states, various reform measures have to be undertaken to develop agriculture marketing. These measures concentrate on the numerous areas, specifically infrastructure development, information provision, improving the role of private sector and decreasing government sector intervention, training of farmers and traders in marketing and post-harvest issues, and most importantly creating a competitive national market for food commodities. The Indian government established e-NAM as a first step toward inducing competition in the agricultural market in 2016. The e-NAM or the National Agriculture Market, is a pan-India electronic trading portal which integrates the existing APMC mandis to create a unified national market for agricultural commodities. In this backdrop, this paper examines whether the introduction of e-NAM by the government has improved the spatial integration of onion markets in India. Using the maximum likelihood method of cointegration, it investigates onion market price integration of Maharashtra , Karnataka , Rajasthan , West-Bengal with the average wholesale onion price of India for the period 2010-2016 (before e-NAM) and 2016-2019 (after e-NAM). It provides evidence in favour of market integration for the period 2016-2019, while multiple relations are found to govern onion prices across states during 2010-2016. The evidence in effect suggests that introduction of e-NAM in 2016 has improved market integration for onion market prices in India.

Keywords: Unit root, Cointegration, Spatial Market Integration, Onion market, e-NAM, India

JEL Classification: C22, C32, O53, Q11.

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1. Introduction

Stabilising food inflation is a major policy challenge in India. Apart from demand and supply side factors and the factors related to government policies behind high and sticky food inflation in India (Gulati et al., 2013; Gulati & Saini, 2013; Gokarn, 2011; Bandara, 2013; Gulati & Shweta 2013; Ganguly & Gulati, 2013, Bhattacharya & Sen Gupta, 2017), recent studies highlight market distortions as another reason behind persistent food inflation in the country (Chengappa et al., 2012; Tomar, 2013; Lahiri & Ghosh, 2014; ASSOCHAM, 2011; Kumar et al., 2010; Carrasco & Mukhopadhyay, 2012).

A series of market distortionary rules and regulations hinder development of an integrated agricultural market in India. In the agriculture sector, Agriculture Produce Marketing Committee (APMC) and Essential Commodity Act (ECA) are the two major Acts, under which, centre and states impose regulations on trading of commodities thereby impeding the free trade. The main aim behind these Acts is food security and to ensure fair prices to farmers and to control price volatility for consumers by setting the floor price for retailers. However, in the absence of a competitive market and adequate infrastructure, the rent seeking activities of the market agents causes large deviation between wholesale and farmers' prices of food commodities (Gandhi & Namboodiri, 2002; ASSOCHAM, 2011). In this context, Bhattacharya et al. (2019) finds a moderate but significant pass-through of mark-up shocks into both wholesale and retail food inflation in India.

The levies and taxes charged by the states, with the aim of protecting their own socio-economic interest and fiscal revenues, are a major source of market distortion which has been prohibitive towards internal trade in India. These high taxes have significant cascading effects on the prices when the commodities passes through the supply chains, therefore leading to price variations among identical commodities across states.

Some of the other common reasons for the incomplete price transmission of several commodities across states are regional bias in price and procurement policies, non-uniformity in taxes and levies across states, information gap, weak infrastructure, transportation costs for moving commodities across states, and monopsony power of mandis on price formation.

Therefore in order to ensure greater transparency and uniformity of food commodity prices across states, various reform measures have to be undertaken to develop agriculture marketing. These measures concentrate on the numerous areas, specifically infrastructure development; information provision; improving the role of private sector and decreasing government sector intervention; training of farmers and traders in marketing and post-harvest issues; and most importantly creating a competitive national market for food commodities.

The Indian parliament has recently passed the Farmer's Produce Trade and Commerce (Promotion and Facilitation) Bill, 2020, and the Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Bill, 2020 as a major step towards creating a competitive market for food commodities. Under the existing APMC Act, the geographical area of the State is divided into smaller market areas which are managed by a Market Committee constituted by the State Governments. The APMC Act primarily prevents any individual or agency from freely conducting wholesale marketing activities. The Act also prohibits farmers from dealing directly with retailers and requires them to sell their produce to licensed middlemen approved by the Committee. The recently passed farm bills allows selling produces outside the physical territory of the mandis and hence serves an additional marketing channel for the farmers, simultaneously retaining the mandis system under the APMC Act.

Although there are widespread reactions for as well as against the farm bill, government established e-NAM as the first step toward inducing competition in the agricultural market in 2016. The e-NAM or the National Agriculture Market, established since 14th April, 2016, is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities. Mission of e-NAM is integration of APMCs across the country through a common online market platform to facilitate pan-India trade in agriculture commodities.

The emergence of e-NAM is expected to be the game changer in agricultural trading and the potential source of various direct and indirect benefits to the agricultural sector and the economy. Directly, the e-NAM is expected to increase competition in agricultural market, eliminate cartels and price manipulations by local traders, and stabilise price mark ups at both wholesale and retail levels (Chand, 2016). Indirectly, this system would help farmers to find out the market with remunerative prices for the produce, motivating them to investment in productivity enhancement and increase production.

The Cabinet Committee on Economic Affairs approved a budget of Rs. 200 crores on July 1st, 2015 for setting up a common e-platform in 585 selected wholesale markets. The Department of Agriculture and Cooperation provided the software to the states free of cost, along with Rs. 30 lakh per mandi for setting up the required infrastructure. By 15th of May, 2020, 1000 mandies located in 21 states and union territories (UTs) are integrated, around 1.68 crores farmers are registered and Rs. 1.14 lakh crores of trade value has been carried out through e-NAM.[3]

The success of e-NAM depends on how well different markets across India are integrated with each other. In the present study, we examine how effective the e-Nam has been in case of wholesale onion market in India.

The average price inflation of onion in India has been more than 5% on monthly year-on-year (YOY) basis during the last decade of 2010-2019. However there are occasions when we see huge spikes in onion inflation. Onion inflation reached its peak in year 2013, in 2015 and again in 2019. In August 2013, the wholesale inflation was more than 55 %, in Auguat 2015 it went over 56%, and in December 2019 it crossed 53% mark. In this context, we examine to what extent, the wholesale market prices of onion of the four onion producing states in the four regions of the country, namely, Maharashtra, Karnataka, Rajasthan, and West-Bengal are integrated with the average wholesale price of onion in India. We examine the integration of wholesale market of onion in the pre and post e-NAM periods separately. The pre e-NAM period ranges from January 2010 to March 2016. The post e-NAM period spans from April 2016 to December 2019. By using cointegration analysis we assess whether e-NAM facilitates integration of onion market in India.

We find evidence in favor of market integration for the post e-NAM period, while we find absence of market integration for the period prior to the introduction of e-NAM. The evidence in effect suggests that introduction of e-NAM has improved market integration for wholesale onion prices in India.

An extensive literature assess domestic commodity market integration in India as a result of the liberalisation process (Sekhar, 2012; Beag and Singla, 2014). However, to the best of our

[3] https://www.indiabudget.gov.in/doc/Budget_Speech.pdf (Page No. 23, Point 106)

knowledge, effectiveness of e-NAM in integrating domestic commodity markets in India is yet not explored in the literature. Our study attempts to fill this void.

The rest of the paper is organized as follows. Section 2 discusses the existing literature. Section 3 summarises some stylized facts of onion market. Section 4 describes data. Section 5 outlines the methodology. Section 6 discusses the results and finally Section 7 concludes the paper.

2. Literature Review

There exists an extensive strand of literature exploring the market integration aspect of liberalisation of agriculture market in India. Most of these studies have used cointegration method to show how liberalisation has affected the extent of integration in different agricultural commodities markets across the country.

Sekhar (2012) attempted to assess the extent of integration among selected agricultural markets in India. The author used Gonzalo-Granger (G-G) model to examine the extent of market integration. Results indicate that the commodity markets that are not subject to inter-state or inter-regional movement restrictions such as gram and edible oils, appear to be well integrated. However, rice markets, facing the maximum inter-state movement restrictions, do not show integration at the national level.

Behura and Pradhan (1998) used Engel-Granger cointegration method for fish prices in six markets in the state of Orissa. They found that fish markets are not integrated mainly due to poor infrastructural facilities at landing centres as well as at the terminal secondary markets.

Jha et al. (2005) tested for market integration in fifty five wholesale rice markets in India using monthly data from 1970 to 1999. They used cointegration method and showed that the rice market integration in India is incomplete because of excessive government interference.

Jayasuriya et al. (2008) examined the nature of international price transmission into Indian rice markets before and after the liberalisation in 1994 using panel unit root methods in combination with half cycle estimation. Their findings suggest that the integration of domestic market with international market improved significantly after the liberalisation.

Ghosh (2010) used maximum likelihood method of cointegration to investigate whether regional food grain markets in India within and across the states are spatially linked. The study found that prices across different centres within and across sates have exhibited long run spatial linkages, suggesting that all the exchange locations are integrated.

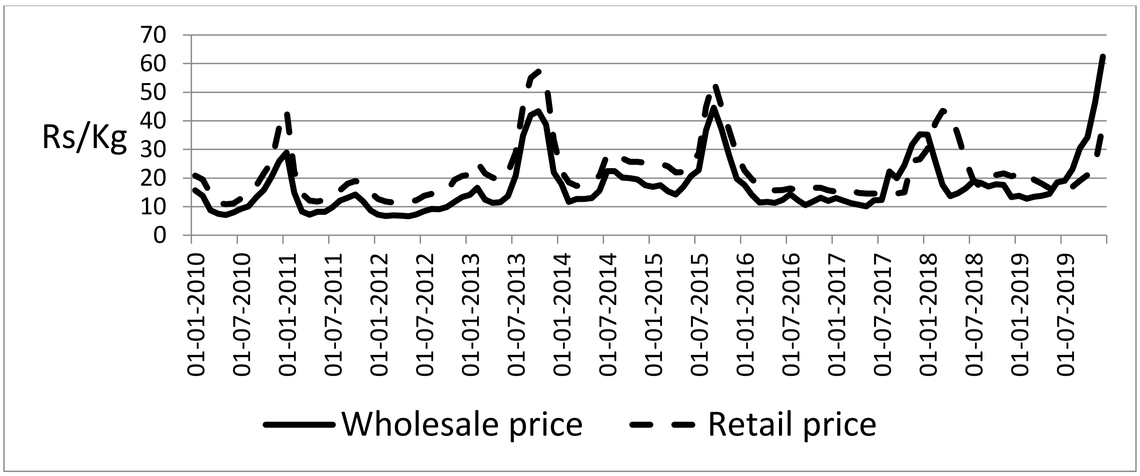
Beag and Singla (2014) investigated market integration across five major wholesale apple markets in Ahmedabad, Bengaluru, Delhi, Hyderabad and Kolkata by adopting Johansen's multivariate cointegration approach and found long-run price integration among the markets.

3. Onion prices: Stylised facts

The average wholesale price of onion has been Rs 17/Kg during the decade of 2010-2019. The average retail price of onion has been Rs 22/Kg during the same period, indicating an average retail mark up of Rs. 5/Kg in the onion market. However, the wholesale price ranges between as low as Rs. 7/Kg to the highest of Rs. 62/Kg. The price dispersion in retail price over the sample period is found to be similar as in the wholesale market. The retail prices of onion ranges between Rs 11/Kg to Rs 57 /Kg.

There are five occasions in ten years, when wholesale onion price experiences large spikes, causing large spikes in the retail prices, too (Figure 1). For instance, the wholesale onion price became one and half times higher than the sample average (Rs. 28/Kg) in January, 2011, causing the retail price to become the double of its sample average (Rs. 43/Kg) in the same month. Again, in September and October, 2013 and in October, 2015, wholesale price of onion crossed Rs 40/Kg mark, causing the retail price to rise over Rs. 50/Kg in those months. The highest spike in the wholesale price is observed in December, 2019 when it surged to more than Rs. 62/Kg, after a relatively lower spike between November, 2017 to January, 2018. The spikes in retail onion prices seem to follow the spikes in the wholesale prices during these periods.

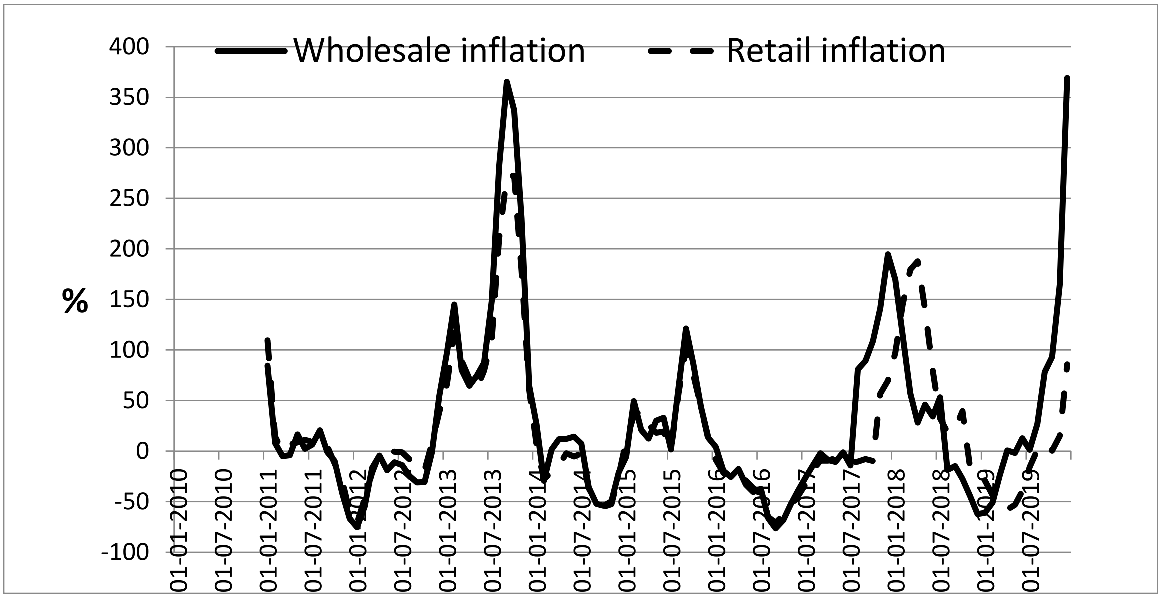
Figure 1: **Average Wholesale and Retail Price of Onion for All India**



Source: Agmarknet, Department of Consumer Affairs, Government of India

During 2010 to 2019, the average monthly year-on-year inflation rates in wholesale and retail onion prices have been 29% and 18% respectively (Figure 2). The average inflation rates in both wholesale and retail onion prices are found to be higher during the pre-NAM period of January, 2011-March, 2016 (32% and 26% respectively) compared to the post e-NAM period of April, 2016-December, 2019 (23% and 7% respectively). However, we do not observe any significant change in the volatility of wholesale and retail onion inflation from pre-NAM (86 and 69 respectively) to post-NAM period (87 and 64 respectively).

Figure 2: **Average Wholesale and Retail Price Inflation in Onion for All India**



Source: Agmarknet, Department of Consumer Affairs, Government of India

4. Methodology

Law of one price (LOP) is the concept for testing market integration. The weak version of LOP says that prices have a proportional relationship and levels differ due to factors like transportation and transfer costs. When the price series p_t^i *and* p_t^e are stationary, we can test LOP or market integration by estimating the regression-

$$lnp_t^i = a + blnp_t^e + \epsilon_t$$

The absolute LOP holds when the restrictions $a \neq 0$ and $b=1$ are satisfied. However, when the price series are non-stationary, co-integration is the appropriate method to test for market integration. Co-integration test evaluates if there is statistically significant linear long run relationships between different price series. Here we have used Johansen's multivariate co-integration method for our analysis.

Johansen's method of co-integration developed by Johansen (1988) and Johansen and Juselius (1990) is outlined as follows. If P_t denotes an (n×1) vector of I (1) prices then the kth order VAR representation of it may be denoted as-

$$P_t = \sum_{i=1}^{k} P_{t-i} + \mu + \beta t + \varepsilon_t \qquad (t=1,23.....T)$$

The procedure for testing co-integration is based on the error correction model (ECM) represented by-

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \prod P_{t-k} + \mu + \beta t + \varepsilon_t$$

Where $\Gamma_i = -\ (I-\Pi_1 - \ldots\ldots - \Pi_i)$; i= 1,2 .....k-1; $\Pi = -(I-\Pi_1-\ldots\ldots-\Pi_k)$; each of Π_i is an n×n matrix of parameters ; ε_t is an identically and independently distributed n-dimensional vector of residuals with zero mean and variance matrix, Ω_t ; μ is a constant term and t is trend. Since P_{t-k} is I(1) , but ΔP_t and ΔP_{t-I} variables are I(0) , equation 2 will be balanced if ΠP_{t-k} is I(0) . So, it is the Π matrix which conveys information about the long run relationship among the variables in P_t . The rank of Π , r , determines the number of cointegrating vectors. If r = n , the variables are stationary in levels. If r = 0, no linear combination of P_t are stationary. If 0< rank (Π) = r < n, and there are n×r matrices α and β such that $\Pi = \alpha\ \beta'$, then it can be said that there are r cointegrating relations among the elements of P_t . The matrix α represents the speed of adjustment parameters. Two likelihood ratio test statistics are used. The null hypothesis of at most r cointegrating vector against a general alternative hypothesis of more than r cointegrating vectors is tested by-

$$\text{Trace statistic } (\lambda\text{- trace}) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i)$$

The null of r cointegrating vector against the alternative of r+1 cointegrating vectors is tested by

$$\text{Maximum eigen value statistic } (\lambda\text{-max}) = -T\ln(1-\widehat{\lambda_{r+1}}).$$

$\hat{\lambda}_i$ s are the estimated eigen values (characteristic roots) obtained from the Π matrix ; T is the number of usable observations.

5. The Data

The data set used in this study consists of monthly wholesale price of Onion for the period from January, 2010 to December, 2019. The data has been quoted from Agmarknet (http://agmarknet.gov.in/). The period from January, 2010 to March, 2016 marks the pre e-NAM period, while the post e-NAM period spans during April, 2016 to December, 2019.

As for the selection of states we have chosen the highest producer states of onion from four different regions of India. We have chosen Maharashtra from West, West Bengal from East, Rajasthan from North and Karnataka from Southern region. For our analysis, onion price of India has also been taken as the average of all states prices available. We have converted the price from rupees/quintal to rupees/ kg for our analysis

Summary Description of Data:

PriceI= Price level of onion in India

PriceM= Price level of onion in Maharashtra

PriceK= Price level of onion in Karnataka

PriceR= Price level of onion in Rajasthan

PriceW= Price level of onion in WestBengal

Table 1: Summary Statistics of Wholesale Onion Prices During Pre e-NAM Period

VARIABLES	MEAN	SD	MEAN (SA)	SD (SA)
PriceI	16.318	8.366	16.163	6.688
PriceM	12.370	6.417	12.239	5.667
PriceK	12.248	7.758	12.216	4.766
PriceR	11.557	10.268	11.475	5.169
PriceW	17.960	9.230	17.870	7.170

Source: Agmarknet, Authors' Estimates

Table 2: Summary Statistics of Wholesale Onion Prices During Post e-NAM Period

Variables	Mean	SD
PriceI	18.974	10.518
PriceM	12.446	10.689
PriceK	13.710	12.519
PriceR	12.445	11.298
PriceW	19.247	13.268

Source: Agmarknet, Authors' Estimates

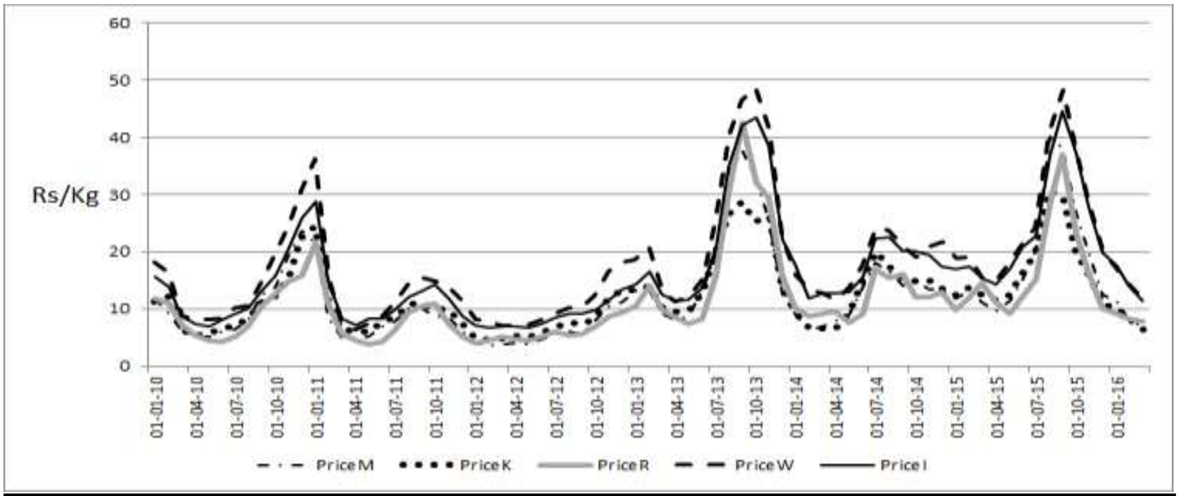
Tables 1 and 2 shows that West Bengal has the highest mean price, whereas, Rajasthan has the lowest mean price during both pre and post e-NAM periods. We also observe that wholesale price of onion in West Bengal depicts highest volatility in both pre and post e-NAM periods among the selected states. We find that onion prices of the four selected states and the all India price contain seasonal variability in the pre E-NAM period but we do not find any seasonality in the post E-NAM period. Hence we conduct the co-integration test on seasonally adjusted price series for the pre E-NAM period.

6. Empirical Analysis

6.1 Pre E-NAM Period:

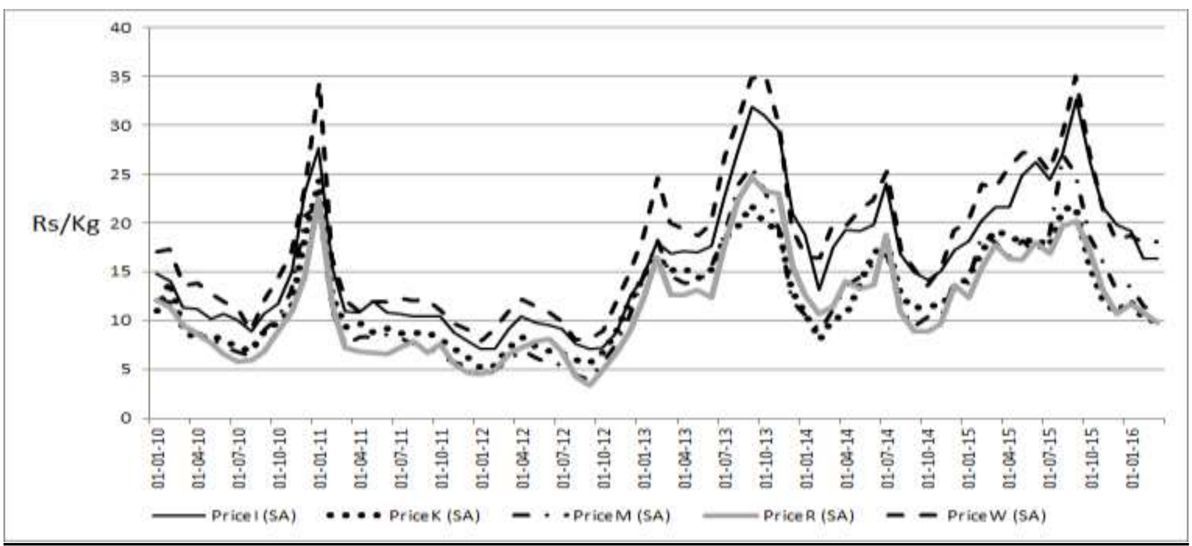
We examine existence of market integration for onion prices before the introduction of E-NAM. Given the availability of data in Agmarket, the pre E-NAM period marks from January 2010 till March 2016 (Figure 3). Before conducting the co-integration test, we need to examine the univariate time series properties of the data. Given that the pre E-NAM period data shows existence of moderate seasonal fluctuations, we conduct our analysis on the seasonally adjusted onion prices for this period (Figure 4). We resort to Augmented Dickey-Fuller test (ADF) to investigate the presence of unit root in the onion price series in the selected four states and in the all India average price.

Figure 3: Pre E-NAM Onion Prices in the Selected States and Average Price for All India



Source: Agmarknet and Department of Consumer Affairs

Figure 4: Pre E-NAM Onion Prices (SA) in the Selected States and Average Price for All India



Source: Agmarknet and Department of Consumer Affairs

The ADF test is based on the statistics obtained from applying OLS method to the following regression equation-

$$\Delta P_t = \mu + \beta t + \theta P_{t-1} + \sum_{i=1}^{k} c_i \, \Delta P_{t-i} + e_t$$

Where P_t is the price series and t is time trend;

and $\Delta P_{t-i} = P_{t-i} - P_{t-i-1}$; $e_t \sim i.i.d.(0, \delta^2)$

The ADF test employs three basic models: Model 1 assumes no constant or deterministic trend present in the series; Model 2 assumes presence of a constant term, but no deterministic trend in the series; Model 3 assumes that the series contains constant and deterministic trend. If the null hypothesis $H_0: \theta = 0$ is retained in any of the above three models using OLS then the series is non-stationary. If the null hypothesis is rejected it is possible to conclude that the series is stationary. For the ADF test to be effective it is needed to choose the lag order so that power of the test is not reduced. We also conduct Phillips and Perron test or PP test that takes into account the possibility of serial correlation and heteroscadasticity present in the series. Both the ADF and the PP tests suggest that the onion price series contain unit root along with a drift and a deterministic trend (Table 3, Model 3). The first difference of log prices are found to be stationary (Table 4).

Table 3: Findings from ADF and PP Tests for Unit Root in Price Levels: Pre e-NAM period

	Model 1		**Model 2**		**Model 3**	
	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP	t statistic ADF	t-statistic PP
PriceM (SA)	-4.008	-2.805	-4.455	-3.083	-0.175	-0.399
PriceK (SA)	-3.928	-2.879	-4.037	-3.053	-0.090	-0.394
PriceR (SA)	-3.730	-2.991	-4.439	-3.374	-0.167	-0.356
PriceW (SA)	-4.095	-2.926	-4.566	-3.306	-0.006	-0.345
PriceI (SA)	-3.612	-2.649	-4.158	-3.106	-0.029	-0.297
c.v5%	-2.912	-2.911	-3.478	-3.476	-2.611	-1.950
c.v1%	-3.459	-3.546	-4.102	-4.097	-1.950	-2.610
c.v10%	-2.591	-2.590	-3.167	-3.166	-1.610	-1.610

Source: Authors' Estimates

Table 4: Findings from ADF and PP Tests for Unit Root for the First Differenced Series: Pre e-NAM period

	Model 1		Model 2		Model 3	
	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP
ΔPriceM (SA)	-5.454	-5.441	-5.400	-5.398	-5.482	-5.484
ΔPriceK(SA)	-5.041	-6.399	-5.015	-6.353	-5.078	-6.439
ΔPriceR (SA)	-5.679	-6.144	-5.623	-6.093	-5.714	-6.192
ΔPriceW (SA)	-5.338	-6.119	-5.294	-6.075	-5.372	-6.164
ΔPriceI (SA)	-5.745	-6.145	-5.698	-6.163	-5.780	-6.187
c.v(1%)	-3.553	-3.548	-4.108	-4.099	-2.612	-2.611
c.v.(5%)	-2.915	-2.912	-3.481	-3.477	-1.950	-1.950
c.v(10%)	-2.952	-2.591	-3.169	-3.166	-1.610	-1.610

Source: Authors' Estimates

Table 5: Findings from Johansen Co-integration Test: Pre e-NAM period

H_0	H_1	λ_{trace}	5%CV	1%CV	λ_{max}	5% CV	1%CV
r=0	r=1	141.43	68.52	76.07	53.91	33.46	38.77
r=1	r=2	87.52	47.21	54.46	43.25	27.07	32.24
r=2	r=3	44.26	29.68	35.65	26.59	20.97	25.52
r=3	r=4	17.66	15.41	20.04	12.66	14.07	18.63

Source: Authors' Estimates

The Johansen Co-integration test results in Table 5 suggest that we reject the null hypothesis of no co integration but we fail to reject the null hypothesis of three co integrating relations. Thus we accept that there are three co integrating equations among the five price series in the pre E-NAM period.

We normalise the coefficients with respect to the overall onion price in India, and onion price in West Bengal and Rajasthan respectively in the three long run equation. The choice of our normalising variavle reles on that West Bengal and Rajasthan are the onion importing states in the sample and hence onion prices in these states are mainly determined by those in Maharashtra and Karnataka, the first and third largest onion supplying states. The three equations can be written as (standard errors are in parenthesis).

$$\log(PriceI) = .96099 + 1.4200_{(.1615)} \log(PriceM) - .68510_{(.1966)} \log(PriceK) \ldots\ldots (1)$$

$$\log(PriceW) = 1.0633 - .35137_{(.1448)} \log(PriceK) + 1.0830_{(.1189)} \log(PriceM) \ldots\ldots (2)$$

$$\log(PriceR) = .24545 + 1.0559_{.1898} \log(PriceM) - .18088_{(.2310)} \log(PriceK) \ldots\ldots\ldots (3)$$

The estimated coefficients indicate the elasticity of onion price in India, West Bengal and Rajasthan with respect to a percentage change in onion prices in Maharashtra and Karnataka.

Three different long run relationships among the onion prices in four states and the overall India suggest that a single long run relation is not governing the price dynamics in the country. Equation (1) suggests that the onion price of India is positively related to onion price of Maharashtra and negatively to onion price of Karnataka, the first and third largest onion supplying states.. Equation (2) suggests a long run relationship among the onion prices in West Bengal, Maharashtra and, while equation (3) shows a relationship among onion prices in Rajasthan, Maharashtra, and Karnataka. All the coefficients are significant expect for the coefficient of PriceK in equation (3). Hence the results suggest that in the pre e-NAM period, onion prices in different states and the overall onion price for India are determined by the prices in the onion supplying states via multiple long run relationships.

Table A.1 in Appendix A reports the long run adjustment coefficients of the VECM specification of onion prices in the selected four states and the average onion price in India. An adjustment parameter indicates the speed at which the short run dynamics of a variable adjust in response to a deviation from the long run relationship. For the system to converge to the long run equilibrium relationship in response to a deviation from it, the sign of adjustment parameter corresponding to a positive long run coefficient should be negative and vice versa.

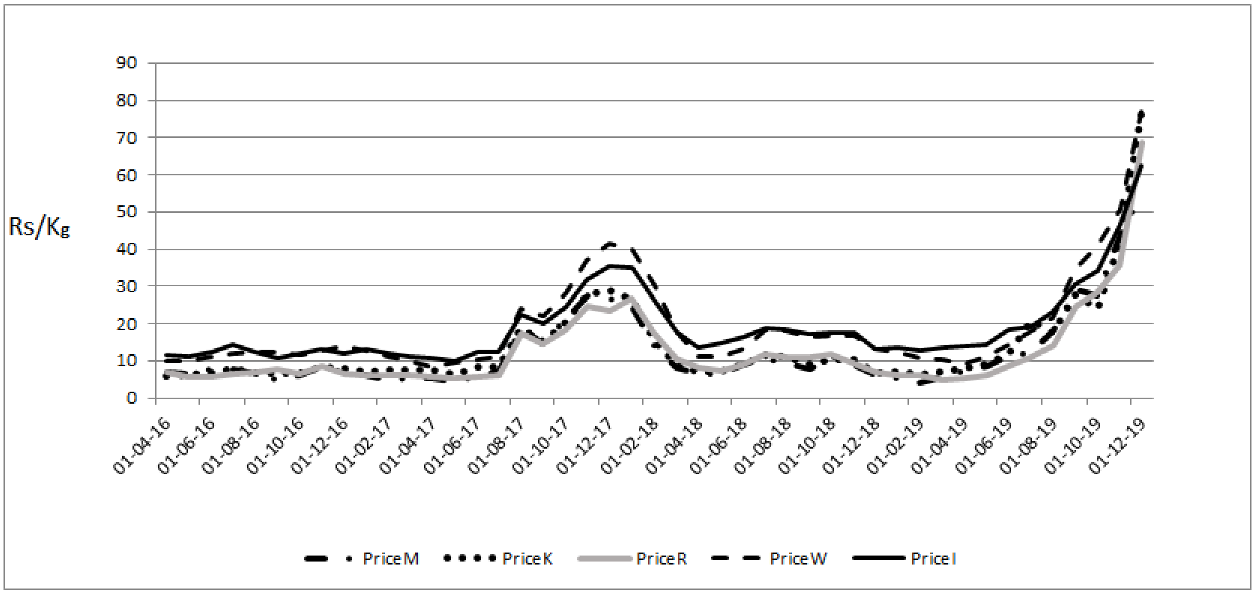
The dynamics of the all India onion price inflation responds to the long run relationship of average onion price in India with those in Maharashtra and Karnataka. Due to a one per cent deviation in the long run equilibrium, the onion price in India adjusts to the deviation at a rate of 62%. The rate of change in the onion price of Maharashtra and Karnataka in the short run are not dependent on any of the long run relationship. The onion price inflation in Rajasthan and West Bengal responds to deviation from their respective long run equilibrium relation at the rate of 98% and 68% respectively.

The Granger causality test results find two-way causality with rate of change in overall onion prices in India and that in each of Maharashtra and Karnataka. This implies that change in onion prices in Maharashtra and Karnataka affects overall onion price in India, while any change in the overall onion prices caused by any other external or internal factors in turn affects onion prices in these two states. Change in overall onion price in India is found to affect the onion price in West Bengal and vice versa. However, no causality is found between the onion price in Rajasthan and the average price in India.

6.2 Post e-NAM Period:

From Table 6, we find that for all the price series in the post e-NAM period, we cannot reject the null hypothesis of unit root with no drift and deterministic trend at both 1% and 5% level of significance. For the first difference of all the price series, the null hypothesis of unit root with no drift and trend is rejected at 10% level (Table 7). Hence the onion prices across the selected states and the overall onion price for India are found to be I(1). The presence of unit root for all the price series justifies resorting to cointegration analysis.

Figure 5: Post e-NAM Onion Prices in the Selected States and Overall Price for All India



Source: Agmarknet, Department of Consumer Affairs

Table 6: Findings from ADF and PP Tests for Unit Rootin Onion Price: Post e-NAM period

	Model 1		Model 2		Model 3	
	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP
PriceM	-1.392	-0.931	0.621	0.818	-1.951	-1.465
PriceK	-0.288	-0.120	1.181	1.288	-0.902	-0.799
PriceR	-1.266	-0.791	0.764	0.884	-1.819	-1.341
PriceW	-1.679	-0.899	0.710	0.966	-2.197	-1.341
PriceI	-0.969	-0.619	0.769	1.061	-1.964	-1.381
c.v(1%)	-3.634	-3.621	-2.631	-2.630	-4.214	-4.205
c.v(5%)	-2.952	-2.947	-1.950	-1.950	-3.528	-3.524
c.v(10%)	-2.610	-2.607	-3.199	-3.194	-1.607	-1.608

Source: Authors' Estimates

Table7: Findings from ADF and PP Tests for Unit Root for the First Differenced Series: Post e-NAM period

	Model 1		Model 2		Model 3	
	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP	t-statistic ADF	t-statistic PP
ΔPriceM	-3.505	-4.933	-3.452	-4.877	-3.637	-5.020
ΔPriceK	-5.350	-5.480	-5.195	-5.339	-5.484	-5.594
ΔPriceR	-2.767	-4.607	-2.629	-4.463	-2.901	-4.757
ΔPriceW	-2.821	-3.866	-2.730	-3.757	-2.931	-3.952
ΔPriceI	-2.863	-4.676	-2.739	-4.524	-3.009	-4.793
c.v(1%)	-3.634	-3.628	-2.633	-2.631	-4.224	-4.214
c.v.(5%)	-2.952	-2.950	-1.950	-1.950	-3.532	-3.528
c.v(10%)	-2.611	-2.608	-3.202	-3.197	-1.606	-1.607

Source: Authors' Estimates

Long run relationship

Let us now consider the number of co-integrating vectors. Table 8 reports the co integration analysis for the VAR model with four lags. The lag length has been selected using AIC, SBIC and LR tests.

Table 8: Findings from Johansen Co-integration Test: Post e-NAM period

H_0	H_1	λ_{trace}	5%CV	1%CV	λ_{max}	5% CV	1%CV
r=0	r=1	75.60	68.52	76.07	39.04	33.46	38.77
r=1	r=2	46.56	47.21	54.46	20.05	27.07	32.24
r=2	r=3	26.510	29.68	35.65	15.79	20.97	25.52
r=3	r=4	10.72	15.41	20.04	10.50	14.07	18.63

Source: Authors' estimates

In the above table, we can see that the null hypothesis of r=0 can be rejected at 5% and 1% critical values for both trace statistic and max statistic. However, the null of r=1 against r=2 can not be rejected in both the cases. Hence, we can conclude that there exists oe co integrating relation among the onion price series in the post e-NAM period. It also implies the presence of a common stochastic trend among the price series, implying that they are integrated in the long run.

The estimated long run relationship can be written as (standard errors are in parenthesis)

$$\log(priceI) = 20.4879 + 2.4636_{(1.4460)} \log(priceM) + 1.5373_{(1.1609)} \log(priceK) + 5.7586_{(1.5638)} \log(priceR) - 10.8159_{(2.0161)} \log(priceW) \qquad (4)$$

In the long run in the post e-NAM period, onion price of India is positively related to price of Maharashtra, price of Karnataka and price of Rajasthan. While the relationships with price of Maharashtra and price of Rajasthan are statistically significant, the same with price of Karnataka is not statistically significant. Price of West- Bengal is negatively (statistically significant) related to price of onion of India in the long run.

Table A.2 in Appendix A reports the speed of adjustment of onion prices across states and at the overall country level to a deviation from the single long run equilibrium relation found among them in the post e-NAM period. The results suggest that the short run dynamics of the rate of change in onion prices in India and the states are not governed by the long run relation, except for in West Bengal at 5% level of significance. Our findings suggest that in the post e-NAM period, one single long run relationship governs the price dynamics of onion prices among the onion producing states of the four regions and the overall onion price in India, while their short run dynamics are independent of the long run relationship. Hence in the post e-NAM period the sign of market integration is observed in the long run.

In the post e-NAM period, the pattern of causality remains broadly the same, except for any shock to overall onion price in India does not seem to cause changes in onion price in Maharashtra.

7. Conclusion:

A series of market distortionary rules and regulations hinder development of an integrated agricultural market in India. Apart from various other reform measures including infrastructural development and institutional changes, the Indian government established e-NAM as a first step toward inducing competition in the agricultural market in 2016. The e-NAM or the National Agriculture Market is a pan-India electronic trading portal which integrates the existing APMC mandis to create a unified national market for agricultural commodities.

In this paper, we examine whether the introduction of e-NAM by the government has improved the spatial integration of onion markets in India. Using the maximum likelihood method of cointegration, it investigates onion market price integration of Maharashtra, Karnataka, Rajasthan, West-Bengal with the average wholesale onion price of India for the period 2010-2016 (before e-NAM) and 2016-2019 (after e-NAM).

We find evidence in favor of market integration for the period of 2016-2019, while multiple relations are found to govern onion prices across states during 2010-2016. The evidence in effect suggests that introduction of e-NAM in 2016 has improved market integration for onion prices in India. Our findings suggest that e-NAM promotes integrity in onion marketing by streamlining of procedures across the integrated markets, removing information asymmetry between buyers and sellers and promoting real time price discovery based on actual demand and supply.

While NAM is a major shift in policies related to agricultural marketing, there have been decade old efforts to enhance efficiency in agricultural trading under APMC. The introduction of model APMC Act 2003 has been an effort to overcome some of the shortfalls in the APMC Act, 1950. For instance, the model APMC act has provisions for (i) direct selling by farmers to contract farming sponsors, (ii) setting up of new market area by private persons, farmers and consumers, (iii) direct interaction between farmers and consumers, (iv) single levy of market fee on sale in any market area, and (v) replacement of multiple licensing system with single registration of market functionaries to operate in multiple market areas. Yet, the model APMC Act has grossly been a failure, due to reluctance on part of state governments to reform the APMC legislation, as the modified Act would result in huge revenue loss for them. Hence, in the absence of a legal framework to replace the existing APMC Act with multiple licenses and market fees, with a system of single license across states, single point levy of market fees and provision of inter-state trade, the integration of markets across states would remain incomplete.

In this backdrop, the Indian parliament has recently passed the Farmer's Produce Trade and Commerce (Promotion and Facilitation) Bill, 2020, and the Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Bill, 2020 as a major step towards promoting competitive market for food commodities. The recently passed farm bills allows selling produces outside the physical territory of the mandis and hence serves an additional marketing channel for the farmers, simultaneously retaining the mandis system under the APMC Act. The new farm bill has created wide-spread reactions, agitation and protests against it across the country. It is also true that APMC Act is not solely responsible for the segmented agricultural market in India. The examples are Kerala and Bihar. Kerala never adopted the APMC Act, and Bihar abandoned it in 2006. The situation in these two states are no better than other states. Karnataka, on the other hand, stands as an exception with a plan prepared in 2012-13 to integrate its mandis and automate the auction process using an e-trading platform. The integration process has been conducted with the assistance of National Commodity and Derivatives Exchange (NCDEX Spot Exchange) and Rashtriya e-Marketing Services (ReMS), a Private Limited Company, in a public-private partnership framework. The Karnataka model, implemented in February, 2014 finally emerged as the role model for e-NAM.

The success of developing a virtual and physically integrated agricultural commodity market across the states in India ultimately depends on a large number of factors. Under e-NAM, and the in the ideal physically integrated market, mandis constitutes the first layer of integration. However, in reality, the first layer of agricultural trade takes place at the farm-gate level. Farmers, mostly the small and medium farm-owners sell off the produce to big traders or produce aggregators at the farm-gate. Unless farmers in a neighbourhood of a particular mandi can collectively aggregate their produce and bring to the mandi themselves, the benefit of on-line realisation of remunerative prices at the mandi level may not be realised.

Further, If farmers individually cannot access local mandis, it would be difficult for them to make their produce available to buyers in other states. Again the cost of transports to markets in other states may be prohibitive for small and medium farmers, and hence, taking advantage of better price realisation in other states may not be feasible for them. In a nutshell, to make the process of agricultural market integration sustainable, it is essential to build a public-private partnership (PPP) model to maintain information and payment flow through an electronic system, to provide processing and storage facilities at the mandi level, and to provide of transport facility for smooth movements of agricultural produce from one state to another.

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Appendix A

Table A.1: Long run adjustment coefficients for the pre e-NAM period

Equation	Coefficient of EC	Standard Error	z	p>|z|
D_logPrice (SA)				
(Equation1)	**-.6199662**	**.1898454**	**-3.27**	**0.001**
(Equation2)	**.1645787**	**.3080084**	**0.53**	**0.593**
(Equation 3)	**-.2431605**	**.1833059**	**-1.33**	**0.185**
D_logPriceM (SA)				
(Equation1)	**-.175851**	**.2581209**	**-0.68**	**0.496**
(Equation2)	**-.0614628**	**.4187796**	**-0.15**	**0.883**
(Equation3)	**-.3980985**	**.2492294**	**-1.60**	**0.110**
D_logPriceK (SA)				
(Equation1)	**-.4289215**	**.223671**	**-1.92**	**0.055**
(Equation2)	**-.1956033**	**.3628875**	**-0.54**	**0.590**
(Equation3)	**-.199759**	**.2159662**	**-0.92**	**0.355**
D_logPriceR (SA)				
(Equation1)	**-.3203346**	**.2439453**	**-1.31**	**0.189**
(Equaton2)	**.5101805**	**.3957809**	**1.29**	**0.197**
(Equation3)	**-.9809032**	**.2355422**	**-4.16**	**0.000**
D_logPriceW (SA)				
(Equation1)	**-.1546652**	**.206378**	**-0.75**	**0.454**
(Equation2)	**-.6764736**	**.3348312**	**-2.02**	**0.043**
(Equation3)	**-.1932481**	**.199269**	**-0.97**	**0.332**

Source: Authors' estimates

Table A.2: Long run adjustment coefficients for the post e-NAM period

Equation	Coefficient of EC	Standard Error	z	p>|z|
D_logI	-.068	.037	0.590	.094
D_logM	-.123	.060	1.930	.053
D_logK	-.096	.057	2.380	.057
D_logR	-.072	.057	2.400	.117
D_logW	-.131	.040	2.110	.035

Source: Authors' estimates

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