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Testing the mean reversion in prices of agricultural commodities in India

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Abstract

We tested the mean reversion property of 46 agricultural commodities of India covering the period 2000:M1-2013:M1. In doing so, we used two batteries of time series tests. One battery of test is associated with testing of the null hypothesis of a unit root whereas; second battery of test is associated with testing of the null hypothesis of stationarity. We find the robust evidence of stationarity for Betelnut/Arecanut, Black Pepper, Cardamom, Cummin, Garlic, Ginger (Fresh), Guava, Poultry chicken and Turmeric. This indicates that any policy to influence the prices of these commodities will not have a permanent impact as they have a tendency to revert to the mean. Thus, we recommend to the Policymakers/Government to review the commodity futures ban for these commodities. However, if Government/Policymakers wish to control the food prices, they need to make policies which influence the prices of the commodities exhibiting the unit root behaviour. And any policy shock to these commodities will have the permanent impact and therefore, the Government/Policymaker can consider for commodity futures ban.

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1. Introduction

Inflation is one of the biggest challenge India has been facing, recently. One of the factor causing high inflation is hike in the prices of agricultural commodities, particularly, prices of the food articles. It's prominence in high inflation is due to its larger share, i.e., about 45 per cent in total household expenditure. During the period 2005-06 to 2012-13, food inflation in terms of Wholesale Price Index (WPI) was higher than the overall inflation (i.e., WPI). The quarterly food inflation grew at an average rate of 10.16 per cent during this period, compared with 6.76 per cent of overall inflation. However, during the period 1999-00 to 2005-06, the overall inflation was observed to be higher than the food inflation. This was the period when inflation in general was relatively lower than the average quarterly food inflation. During this period, overall inflation was 4.90 per cent, whereas food inflation was 2.63 per cent. Food items, namely, Cereals, Pulses, Milk, Fruits and Vegetables, Meat-fish-eggs (MFE) and Sugar exhibited higher average rates of inflation than overall rate of inflation during the period. Pulses, MFE, and Milk and Milk products which together constituted around 30 per cent of the total food expenditure in 2009-10 (2004-05=100), as per the 66th NSSO Round) were responsible for about 42 per cent of food inflation during 2012-13Q4 (RBI, 2014).

Besides spikes in the food grain prices, India is confronted with high price volatility. Theoretically also, the storage model explains how speculators will engage in commodity transactions based on their expectations of future price changes. Typically, when the actual price is below the level speculators expect to prevail in the next period, they will store the commodity so that they can sell it at a higher price during the next period (Williams & Wright, 1991). The result of high price volatility is the opening up of futures trading in a large number of agricultural commodities. One of the steps taken by the Government of India (GOI) to control price rise and fluctuations is the ban on commodity futures trading. Futures trading in commodities has a long tradition in India going back to 1875 when the Bombay Cotton Trade Association was set up. This was followed by a mushrooming of exchanges throughout the country. However, futures markets faced near oblivion since 1960'^{s} when they were accused of fuelling inflation and were perceived not to have any role as the State intervened directly in prices and distribution of large number of essential commodities which were perennially in short supply. The market survived in the periphery as very few commodities were permitted for futures trading (GOI, 2008). In January 2007, the Government banned futures trading in Wheat, Rice, Tur and Urad in an attempt to control inflation. The increasing inflation rates were attributed to greater price volatility due to futures trading. On 7th May, 2008, the Government announced a ban on futures trading in four commodities – Chickpea, Potato, Rubber and Soy oil. The argument again was similar that is futures trading merely leads to unnecessary speculation, and pushes the prices up. The first and most obvious effect is the reduction in trading volumes for commodity exchanges. Soy oil, Chickpea and Potato futures had been showing a declining trend, while Rubber futures had been rising for a couple of weeks before the ban due to the rise in Crude oil prices. Spot Rubber prices hit a record Rs.120 on 7th May, 2008, but the ban immediately brought prices down by Rs.4.22. However, the prices rose again in June, despite the ban. Of the four banned commodities, only the prices of Potatoes have decreased steadily since the ban. However, since prices were declining even before the ban, experts have argued that the decrease in prices is due to the bumper crop, and not the ban on trading. In the case of Chickpeas, the prices haven't moved consistently in a particular direction. They declined immediately after the ban but began rising again in June. Rubber and refined Soy oil have shown approximately 31 per cent and 11 per cent increases in price respectively since the ban was imposed (Srinivasan, 2008).

Given the importance of prices of food articles in overall inflation and presence of high price volatility, Government and Policymakers need to know the characteristics of prices of these commodities due to its bearing on agricultural policy implications. In this study, we attempted to analyse the mean reversion characteristic of prices of 46 agricultural commodities in Indian context. Mean reversion (i.e., I(0)) is the process of the price approaching a long term mean, where variance is constant with time and shocks will have only temporary effect. The knowledge about mean reversion of the commodities is much more important in appropriate policy making. For example, if agricultural prices have a tendency to revert to the mean, any policy decision to influence the prices will not be effective and precision of the forecast will be reliable. However, if the agricultural prices have a unit root property (i.e., I(1)), policy decisions will be effective, but the precision of the forecast will not be reliable.

In doing so, we tested the unit root property for the prices of 46 agricultural commodities during 2000:M1-2013:M1. We used two types of tests- one which has the null hypothesis of unit root and second, which has the null hypothesis of stationarity. Results, show the evidence of stationarity in commodities such as Betelnut/Arecanut, Black Pepper, Cardamom, Cummin, Garlic, Ginger (Fresh), Guava, Poultry Chicken and Turmeric, indicating that any policy to influence the prices of these commodities will not have permanent impact and thus be ineffective.

The remainder of the article is organized as follows. The second section specifies the brief review of literature. The third section discusses about the data and methodology used. The fourth section contains the empirical results, followed by the fifth section which represents conclusions and policy implications.

2. A Brief Review of Literature

Several attempts have been made to test the mean reversion property of prices of agricultural commodities. In commodity literature, Schwartz (1997) was the first study to address the mean reversion process. Subsequently, a number of studies made attempt to report the evidence of mean reversion in commodity prices such as Peterson, Ma, and Ritchie (1992); Allen, Ma, and Pace (1994); Walburger and Foster (1995). Tomek and Peterson (2001), Cartea and Figueroa (2005), and Miltersen (2003) have worked on mean reversion in financial commodity prices. Ovararin and Meade (2010) modelled the returns volatility on three agricultural commodities i.e., Rough Rice, Rubber and White Sugar. The study investigated mean reversion and seasonality, and found no evidence of mean reversions in samples. It concluded that seasonality is a crucial determinant providing more realistic volatility model for agricultural products. Jin *et al*. (2010) generalized Schwartz's (1997) two-factor model to allow for mean reversion in spot prices. The results show that commodities exhibit seasonal pattern in the spot prices.

Recently, Chong, Zhang and Feng (2011) have examined the time series properties of China's Consumer Price Index and found that overall inflation and inflation of Food, Tobacco, Clothes, urban transport and urban housing are not persistent. There were structural breaks in the inflation series in 2003 and 2004. They had used unit root test of Zivot and Andrews (1992) (hereafter ZA) unit root test with one structural break and the unit root test with two breaks suggested by Lumsdaine and Papell (1997) (hereafter LP). Tiwari and Suresh (2012) revisited the same context and found that national, urban and rural series of the overall inflation**,** Clothing, and Food, a national series of education and residence and the rural series of residence and education are stationary. All these studies were related to the mean reversion property outside India. However, to the best of our knowledge there are only two studies which made an attempt to analyse the mean reversion property of agricultural commodities in Indian context. Tiwari and Suresh (2012) used more powerful tests of structural breaks (proposed by Lee and Strazicich 2003, 2004; Narayan and Popp 2010). For instance, the study by Gil-ever Alana and Tripathy (2014) found the evidence of mean reversion in prices of five agricultural commodities such as Rice, Wheat, Maize, Bajra and Jowar. However, for agricultural commodities such as Black Gram and Arhar, the null hypothesis of unit root was not rejected. Gil-ever Alana and Tripathy (2014) used fractional unit root tests. Noteworthy to mention that the studies before 2011 had ignored the case of structural breaks and Chong, Zhang and Feng (2011) is the first in this direction. However, the problem of low power of unit root test with structural breaks was overcome by Tiwari and Suresh (2012). But Gil-ever Alana and Tripathy (2014) raised the issue related to fractional integration. The present work extends the studies not only in terms of incorporating the structural breaks but also addressing the volatility behaviour and hetroskedasticity. This we did by relying on powerful unit root tests that are robust to the structural breaks, volatility and hetrosskedasticity. Besides, there is no study except Gil-ever Alana and Tripathy (2014) which analysed just five commodities, we analysed the unit root behaviour for 46 agricultural commodities.

3. Data and Methodology

3.1 Data

The data on agricultural commodity prices is collected from the Central Statistical Organization (CSO), Government of India. The study period is 2000:M1 to 2013:M1. It is well known that the agricultural commodities are seasonal in nature which may lead to bias in the unit root analysis and therefore, inference drawn would not be reliable. To overcome the problem of seasonality we did seasonal adjustment in the data using Census-X12 method before our all empirical estimations.

3.2 Methodology

3.2.1 *"Classical"* unit root tests

In the first step we used, most popular, (Augmented) Dickey and Fuller (hereafter, DF/ADF) (1981) test which was followed by some other popular unit root test such as Elliott-Rothenberg-Stock (1996) and Ng-Perron (2001).

3.2.2 Powerful unit root tests

The Kwiatkowski, Phillips, Schmidt and Shim (hereafter, KPSS) (1992) proposed a test, (generally known as a KPSS test statistic) for the first order (level) stationarity which is defined as follows:

$$KPSS = \frac{1}{(\hat{w}T)^2}\sum_{k=1}^{T}\left(\sum_{t=1}^{k}(y_t - \bar{y}_t)\right)^2 \qquad (1)$$

where is $\bar{y}_t$ the sample mean of $\{y_t\}_{t=1}^{T}$ and $\hat{w}^2$ is a nonparametric consistent estimator of the long-run variance. Under the null hypothesis of level stationarity, KPSS test statistic also can be represented as:

$$KPSS \overset{d}{\Rightarrow} \int_0^1 \kappa(\alpha)^2 d\alpha, \qquad (2)$$

where $\kappa(\alpha) := W(\alpha) - \alpha W(1)$ is the standard Brownian bridge.

Recently, De Jong et al. (2007) proposed a robust version of the KPSS test (we call it IKPSS test statistic) based on the following empirical process:

$$I_T(r) := \frac{1}{\hat{\sigma}\sqrt{T}} \sum_{t=1}^{[T_r]} sign(y_t - m_T) \tag{3}$$

where m_T is the sample median of $\{y_t\}_{t=1}^{T}$ and $\hat{\sigma}^2$ is a nonparametric consistent estimator of the long-run variance

$$\sigma^2 = \lim_{T\to\infty} \mathrm{E}\left[\left(\frac{1}{\sqrt{T}} \sum_{t=1}^{[T]} sign(y_t - m_T)\right)^2\right]$$

And

$$sign(x) := \begin{cases} 1 & if \ \ x > 0 \\ 0 & if \ \ x = 0 \\ -1 & if \ \ x < 0 \end{cases}$$

The fluctuation of the empirical process $I_T(r)$ is measured by $h(I_T(r))$ where $h(\cdot)$ is the Cramér-von Mises metric. Thus the IKPSS test statistic can be expressed as:

$$IKPSS := \frac{1}{(\hat{\sigma}T)^2} \sum_{k=1}^{T} \left(\sum_{t=1}^{k} sign(y_t - m_T) \right)^2 \tag{4}$$

De Jong et al. (2007) show that under the null hypothesis of level stationarity IKPSS test statistic has the same limiting distribution as the KPSS test statistic i.e., $IKPSS \overset{d}{\Rightarrow} \int_0^1 \kappa(\alpha)^2 \, d\alpha$. We should note that, when the alternative hypothesis is unit root, the IKPSS has correct size under the presence of fat-tailed errors while the KPSS test does not. And when the tails are thin the IKPSS test has lower power than the KPSS test. However, when the aforementioned traditional stationarity tests are applied to test the stationarity, it is difficult to detect alternatives with unconditional volatility (distribution scale) that changes over time. To overcome this issue Xiao and Lima (2007) proposed a test (we call it XL) for second order (covariance) stationarity based on the following standardized bivariate empirical process:

$$Z_T(r) := \frac{1}{\sqrt{T}} \hat{\Omega}^{-1/2} \sum_{t=1}^{[T_r]} \begin{pmatrix} \tilde{y}_t \\ v_T \end{pmatrix} \tag{5}$$

where $\tilde{y}_t := y_t - \frac{1}{T}\sum_{j-1}^{T} y_j$ is the demeaned data, $v_t := \tilde{y}_t^2 - \sigma_y^2$, $\sigma_y^2 := \frac{1}{T}\sum_{t=1}^{T} \tilde{y}_t^2$ and $\hat{\Omega}^{-1/2}$ is the inverse of the Choleski decomposition of $\hat{\Omega}^2$ a nonparametric consistent estimator of the long-run variance

$$\Omega^2 = \lim_{T\to\infty} \mathrm{E}\left[\left(\frac{1}{\sqrt{T}} \sum_{t=1}^{T} \begin{pmatrix} \tilde{y}_t \\ v_t \end{pmatrix}\right)\left(\frac{1}{\sqrt{T}} \sum_{t=1}^{T} \begin{pmatrix} \tilde{y}_t \\ v_t \end{pmatrix}\right)'\right]$$

Then, Xiao and Lima (2007) applied the Kolmogorov metric to measure the fluctuation of the empirical process $Z_T(r)$ and defined their test statistic as follows:

$$XL = \max_{1\le k\le T} \left\| \frac{1}{\sqrt{T}} \hat{\Omega}^{-1/2} \sum_{t=1}^{k} \begin{pmatrix} \tilde{y}_t \\ v_t \end{pmatrix} \right\|_1 \tag{6}$$

Under the null hypothesis of covariance stationarity the test statistic can be expressed as:

$$XL \overset{d}{\Rightarrow} \sup_{0\le r\le 1} \left\| \begin{pmatrix} W_1(r) - rW_1(1) \\ W_2(r) - rW_2(1) \end{pmatrix} \right\|_1 \tag{7}$$

where $(W_1(r) - rW_1(1)\ W_2(r) - rW_2(1))'$ is the 2-dimensional standardized Brownian bridge. The critical values can be found in Xiao and Lima (2007). Unlike the KPSS or the IKPSS, the XL test has power not only against the alternative hypothesis of distribution (location) varying in time, but also against the alternative hypothesis of the distribution scale (unconditional volatility) varying in time. However, all of the aforementioned tests have power close to size against the alternative hypothesis of time-varying Kurtosis. As Busetti and Harvey (2007) discuss, the distribution of a random variable may present changes over time that does not impact the level or the variance.

For instance, may be the asymmetry or fatness of the tail is time-varying. This is particularly important in analysing financial time-series. To exemplify this point, consider how changes in lower tail quantiles may impact decisions of a risk manager or a regulatory agency.

To overcome the problem of aforementioned unit root test Lima and Neri (2013) (we call it LN) propose a new test for the null hypothesis of strict stationarity generalizing the IKPSS test in terms of using the sign of the data minus the sample quantiles whereas the IKPSS test uses the sign of the data minus the sample median only. Thus the LN test has power not only against the unit root alternative, alternatives to the structural changes in the mean and alternatives with the unconditional heteroskedasticity, but also has good power in detecting changes in higher moments of the unconditional distribution unlike the KPSS, IKPSS and XL tests. The estimation procedure of LN test can be explained as follows:

Let $\{y_t\}_{t=1}^T$ be the data and, for $\tau \in [0,1]$, define

$$b(\tau) := \arg\max_{b \in R} \sum_{t=1}^{T} \rho_\tau (y_t - b), \tag{8}$$

where

$$\rho_\tau(u) = (1_{u<0} - \tau)u.$$

Therefore, $b(\tau)$ is simply the τ^{th} sample unconditional quantile of $\{y_t\}_{t=1}^T$. Notice that ρ_τ is not everywhere differentiable but, since it is convex, we can still compute the subgradient. The subgradient plays the same role in quantile estimation as the score function in maximum likelihood estimation. The subgradient of ρ_τ is given by $\psi_\tau(u) = 1_{u<0} - \tau$.

We now define the empirical process

$$S_T(r,\tau) := \frac{1}{\hat{\pi}(\tau)\sqrt{T}} \sum_{t=1}^{[Tr]} \psi_\tau (y_t - b(\tau)), \tag{9}$$

where $r \in [0,1]$, and $\hat{\pi}(\tau)^2$ is a nonparametric consistent estimator of

$$\pi(\tau)^2 := \lim_{T \to \infty} E\left[\left(\frac{1}{\sqrt{T}} \sum_{t=1}^{T} \psi_\tau (y_t - b_0(\tau)) \right)^2 \right],$$

where $b_0(\tau)$ is the population τ^{th} unconditional quantile of the $\{y_t\}_{t=1}^T$.

By using the Kolmogorv-Smirnoff metric to measure the fluctuation of $S_T(r,\tau)$ across various quantiles $\tau \in \Gamma_w = [w, 1-w]$, for some $w \in (0, 1/2)$, the LN test statistic for strict stationarity can be expressed as follows:

$$LN = \max_{\tau \in \Gamma_w} \max_{1 \le k \le T} \frac{1}{\hat{\pi}(\tau)\sqrt{T}} \left| \sum_{t=1}^{k} \psi_\tau (y_t - b(\tau)) - \frac{k}{T} \sum_{t=1}^{T} \psi_\tau (y_t - b(\tau)) \right|. \tag{10}$$

$\hat{\pi}(\tau)^2$ can be computed as the HAC estimator,

$$\hat{\pi}(\tau)^2 := \frac{1}{T}\sum_{i=1}^{T}\sum_{j=1}^{T} K\left(\frac{i-j}{q_T}\right)\psi_\tau(y_i - b(\tau))\psi_\tau(y_j - b(\tau)),$$

where K is a kernel function.

4. Data Analysis, Findings and Discussion

Before, we proceed for the estimation of unit root, we analysed the descriptive statistics of the variables. Results of descriptive statistics are presented in Table 1. From the Jarque-Bera test of normality we conclude that only Betelnut/Arecanut, Brinjal, Garlic, Onion, Papaya are normally distributed series as the null hypothesis of normal distribution is not rejected for these commodities and for the rest of the commodities it is rejected, indicating that the rest of the series follow non-normal distribution. Further, Betelnut/Arecanut, Chillies (Dry), Coconut (Fresh), Coffee, Corriander, Ginger (Dry), Ginger (Fresh), Guava, Papaya and Potato are the commodities exhibiting negative Skewness and the other commodities show positive Skewness. Black Pepper shows the maximum mean, whereas Ginger (Fresh) show the minimum mean.

Table 1: Descriptive Statistics of the Variables

Variables	**Mean**	**Median**	**Maximum**	**Minimum**	**Std.Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
Food Article								
A. Cereals								
Bajra	4.841	4.775	5.536	4.358	0.297	0.401	2.168	8.735[b]
Barley	4.859	4.820	5.358	4.427	0.246	0.231	2.079	6.948[b]
Jowar	4.881	4.808	5.568	4.359	0.346	0.446	2.030	11.363[a]
Maize	4.852	4.766	5.521	4.474	0.279	0.732	2.434	16.125[a]
Ragi	4.843	4.703	5.771	4.415	0.326	0.889	2.863	20.813[a]
Rice	4.829	4.724	5.304	4.572	0.223	0.614	1.806	19.191[a]
Wheat	4.847	4.787	5.312	4.553	0.236	0.320	1.620	15.136[a]
B. Pulses								
Arhar	4.833	4.703	5.579	4.389	0.335	0.505	1.839	15.490[a]
Gram	4.914	4.953	5.669	4.398	0.278	0.750	3.340	15.493[a]
Masur	4.879	4.766	5.519	4.421	0.330	0.347	1.641	15.222[a]
Moong	5.000	4.893	5.797	4.554	0.379	0.607	1.919	17.282[a]
Urad	5.065	5.033	5.679	4.555	0.330	0.206	1.816	10.277[a]
C. Fruits								
Banana	4.747	4.753	5.428	4.128	0.312	0.167	2.218	4.727[c]
Coconut (Fresh)	4.467	4.461	4.857	3.953	0.189	-0.452	3.271	5.847[c]
Cashew nut	4.750	4.666	5.327	4.423	0.255	0.911	2.638	22.582[a]
Guava	4.581	4.663	5.458	3.006	0.406	-0.780	4.313	27.230[a]
Orange	4.842	4.789	5.546	4.052	0.341	0.507	2.468	8.592[b]
Papaya	4.662	4.624	5.634	3.768	0.390	-0.020	2.758	0.392
Pineapple	4.805	4.725	5.514	4.300	0.307	0.627	2.224	14.239[a]
D. Vegetables								
Brinjal	4.771	4.776	5.493	4.120	0.290	0.125	2.329	3.356

Table 1 Continued.....

Cabbage	4.923	4.864	6.364	4.164	0.378	0.865	4.264	30.042^{a}
Ginger (Fresh)	4.377	4.410	5.009	3.700	0.293	-0.537	2.796	7.836^{b}
Okra(Lady finger)	4.801	4.741	5.828	4.305	0.341	0.867	2.967	19.713^{a}
Onion	4.884	4.833	6.172	4.096	0.407	0.201	2.265	4.590
Potato	4.704	4.754	5.477	3.697	0.421	-0.584	2.945	8.968^{b}
Sweet Potato	4.841	4.864	5.576	4.065	0.371	0.057	2.042	6.083^{b}
Tapioca	4.949	4.781	5.858	4.185	0.451	0.491	2.005	12.798^{a}
E. Milk								
Milk	4.779	4.676	5.3501	4.368	0.286	0.791	2.194	20.642^{a}
F. Eggs,Meat & Fish								
Beef & Buffalo Meat	4.744	4.736	5.333	4.226	0.348	0.350	1.941	10.539^{a}
Egg	4.794	4.714	5.345	4.438	0.246	0.664	2.181	15.923^{a}
Fish-Inland	4.795	4.642	5.770	4.220	0.409	0.983	2.774	25.646^{a}
Fish-Marine	4.861	4.757	5.691	4.316	0.395	0.684	2.181	16.633^{a}
Mutton	4.835	4.759	5.410	4.390	0.307	0.529	1.827	16.324^{a}
Pork	4.829	4.720	5.503	4.130	0.403	0.004	1.847	8.687^{b}
Poultry Chicken	4.823	4.874	5.310	4.463	0.194	0.055	1.916	7.758^{b}
G. Condiments & Spices								
Betelnut/Arecanut	4.819	4.922	5.471	4.063	0.359	-0.254	2.427	3.830
Black Pepper	5.136	5.172	6.295	4.328	0.548	0.462	2.224	9.523^{a}
Cardamom	5.006	4.928	5.998	4.290	0.463	0.513	2.030	13.042^{a}
Chillies (Dry)	5.004	5.012	5.717	4.280	0.370	-0.024	2.032	6.144^{b}
Corriander	5.007	5.031	5.947	3.673	0.462	-0.535	3.155	7.665^{b}
Cummin	4.909	4.847	5.507	4.486	0.257	0.309	1.922	10.103^{a}
Garlic	4.902	4.799	6.266	3.770	0.590	0.159	2.316	3.725
Ginger (Dry)	4.496	4.543	4.832	3.943	0.188	-0.605	2.856	9.728^{a}
Turmeric	4.856	4.702	6.076	3.795	0.539	0.482	2.693	6.714^{b}
H. Other Food Articles								
Coffee	4.900	5.027	5.868	3.706	0.639	-0.292	1.786	11.870^{a}
Tea	4.811	4.747	5.359	4.397	0.241	0.466	2.140	10.531^{a}

Note: Superscripts a, b and c denote rejection of the null hypothesis at the 1%, 5% and 10% levels of significance, respectively.
Source: Authors' compilations.

The descriptive statistics show that most of the series have non-normal distribution, thus unit root tests based on the assumption of normality may be misleading. In order to have reliable results, we used two batteries of tests, namely, "Classical" unit root tests and the "Powerful" stationarity tests. In the classical unit root tests, we used ADF test (1981), DF-GLS test (1996) and NP test (2001) whereas, KPSS, IKPSS, XL and SS test are used as a powerful stationarity test. Further, for the powerful tests, we generated the bootstrapped p-values with 10,000 replications. It is important to note that all the classical unit root tests have a null hypothesis of unit root, whereas all powerful stationarity tests have a null hypothesis of stationarity. So, we can also refer classical tests as tests of unit root, whereas powerful tests can be referred as tests of stationarity. All results related to unit root/stationarity analysis are reported in Table 2.

ADF unit root test results show the null hypothesis of unit root is rejected for commodities such as Barley, Betelnut/Arecanut, Brinjal, Cabbage, Guava, Onion, Papaya, Sweet Potato, Urad. However, DF-GLS unit root test, which has more power vis-à-vis to the ADF test, show that the null hypothesis of unit root is rejected for Banana, Garlic, Onion, Orange, Papaya, Potato, Sweet Potato, Turmeric, Urad. The most powerful unit root test i.e., NP (2001) show that only Banana, Okra (Lady Finger), Onion, Orange, Papaya, Potato, Sweet Potato are the stationary commodities as the null hypothesis of a unit root for these commodities is rejected.

Now, if we consider the case of powerful tests, we find that the null hypothesis of stationarity is not rejected for Betelnut/Arecanut, Black Pepper, Cardamom, Cummin, Garlic, Ginger(Fresh), Guava, Poultry Chicken, and Turmeric by at least one of the tests among the four stationarity tests. Thus, Betelnut/Arecanut, Black Pepper, Cardamom, Cummin, Garlic, Ginger (Fresh), Guava, Poultry Chicken and Turmeric are the commodities that revert to the mean. From the policy perspective, implication of this finding is that any effort on the part of Policymakers to influence the lasting impact on the prices of such commodities will be ineffective. For the rest of the commodities, the powerful tests reject the null hypothesis of stationarity, providing support for existence of unit root characteristics. From the policy perspective, efforts from Policymakers will bring the lasting impact on the prices of these commodities.

Table 2: Results of Mean Reversion: *"Classical Unit root Test"* and Powerful Stationarity Tests

	***"Classical"* Unit root Tests (Tests Statistics are Reported in the Parenthesis)**				**Powerful Unit root Tests (Bootstrapped p-Values with 10,000 Replications are Reported in the Parenthesis)**			
Variables	**Dickey and Fuller (1981)**	**Elliott-Rothenberg-Stock (1996)**	**Ng-Perron (2001)**					
	ADF(tau3)	**DF-GLS**	**MZ_a**	**MZ_t**	**KPSS**	**IKPSS**	**XL**	**SS**
Food Article								
A. Cereals								
Bajra	-1.811	-0.465	-0.219	-0.123	2.920 (0.000)	2.699 (0.000)	2.988 (0.020)	2.845 (0.000)
Barley	**-3.388**^{C}	-1.238	-3.410	-1.181	2.842 (0.000)	2.635 (0.000)	2.860 (0.034)	2.798 (0.000)
Jowar	-1.867	-0.839	-2.714	-1.125	3.011 (0.000)	2.780 (0.000)	3.228 (0.006)	2.842 (0.000)
Maize	-0.648	-0.826	-1.274	-0.511	2.935 (0.000)	2.709 (0.000)	3.459 (0.001)	2.845 (0.000)
Ragi	-0.432	-0.941	0.268	0.115	2.808 (0.000)	2.673 (0.000)	3.221 (0.005)	2.842 (0.000)
Rice	-1.676	-0.980	-0.310	-0.194	2.884 (0.000)	2.403 (0.001)	3.303 (0.004)	2.833 (0.000)
Wheat	-2.221	-1.684	-8.872	-2.037	3.044 (0.000)	2.704 (0.000)	3.387 (0.002)	2.845 (0.000)
B. Pulses								

Table 2 Continued...

Arhar	-2.255	-1.755	-6.138	-1.751	2.831 (0.000)	2.478 (0.000)	3.096 (0.010)	2.812 (0.000)
Gram	-1.598	-1.722	-6.496	-1.715	2.369 (0.000)	2.713 (0.000)	3.349 (0.004)	2.845 (0.000)
Masur	-2.008	-1.817	-6.745	-1.833	2.724 (0.000)	2.491 (0.000)	3.159 (0.005)	2.825 (0.000)
Moong	-2.388	-2.205	-10.60	-2.295	2.748 (0.000)	2.582 (0.000)	3.647 (0.000)	2.833 (0.000)
Urad	-4.497[a]	**-3.562[a]**	-5.647	-1.679	2.333 (0.001)	2.330 (0.001)	3.093 (0.016)	2.701 (0.002)
C. Fruits								
Banana	-2.763	**-2.788[C]**	**-38.26[a]**	**-4.234[a]**	3.141 (0.000)	2.748 (0.000)	3.055 (0.020)	2.821 (0.000)
Coconut (Fresh)	-1.831	-1.783	-6.537	-1.709	1.715 (0.004)	1.159 (0.025)	2.669 (0.031)	2.143 (0.043)
Cashew nut	-2.525	-1.206	-3.165	-1.157	2.741 (0.000)	2.668 (0.000)	3.335 (0.003)	2.713 (0.001)
Guava	**-4.255[a]**	-1.393	-4.335	-1.324	2.171 (0.001)	1.393 (0.023)	**2.437 (0.110)**	2.538 (0.004)
Orange	-2.865	**-2.835[C]**	**-14.61[C]**	**-2.703[C]**	2.653 (0.000)	2.007 (0.004)	2.935 (0.018)	2.734 (0.001)
Papaya	-3.366[b]	**-3.121 [b]**	**-17.92[B]**	**-2.934[B]**	2.657 (0.000)	2.549 (0.000)	2.913 (0.011)	2.770 (0.000)
Pineapple	-2.013	-2.201	- 7.0267	-1.831	2.561 (0.000)	1.883 (0.008)	2.912 (0.025)	2.636 (0.003)
D. Vegetables								
Brinjal	**-6.805[a]**	-1.078	-1.357	-0.771	2.800 (0.000)	2.562 (0.000)	3.121 (0.007)	2.669 (0.001)
Cabbage	**-3.156[c]**	-0.869	-7.126	-1.882	1.881 (0.002)	2.200 (0.001)	2.937 (0.006)	2.492 (0.004)
Ginger (Fresh)	-2.324	-2.356	- 10.594	-2.281	**0.247 (0.581)**	**0.216 (0.569)**	**1.587 (0.590)**	**1.767 (0.156)**
Okra (Lady finger)	-2.414	-1.579	**-24.00[a]**	**-3.459[a]**	2.726 (0.000)	2.831 (0.000)	3.463 (0.001)	2.772 (0.000)
Onion	**-5.774[a]**	**-5.557[a]**	**-58.47[a]**	**-5.406[a]**	2.536 (0.000)	2.459 (0.000)	2.610 (0.027)	2.616 (0.001)
Potato	-3.423	**-3.573[a]**	**-24.04[a]**	**-3.465[a]**	1.878 (0.000)	1.756 (0.002)	2.482 (0.029)	2.355 (0.005)
Sweet Potato	**-4.857[a]**	**-4.309[a]**	**-30.25[a]**	**-3.846[a]**	2.992 (0.000)	2.620 (0.000)	3.047 (0.010)	2.819 (0.000)
Tapioca	-2.598	-1.464	-3.077	-1.191	2.634 (0.000)	2.365 (0.001)	3.102 (0.006)	2.833 (0.000)
E. Milk								
Milk	-0.770	-1.374	-1.147	-0.624	2.941 (0.000)	2.726 (0.000)	3.499 (0.003)	2.845 (0.000)
F. Egg, Meat & Fish								
Beef & Buffalo Meat	-2.699	-2.406	- 12.186	-2.468	2.996 (0.000)	2.748 (0.000)	3.514 (0.001)	2.842 (0.000)
Egg	-1.535	-1.802	-6.583	-1.755	2.600 (0.000)	2.232 (0.004)	3.192 (0.008)	2.744 (0.001)

Table 2 Continued...

Fish- Inland	-1.650	-0.873	-2.220	-0.836	2.403 (0.000)	1.8928 (0.006)	2.950 (0.024)	2.551 (0.006)
Fish-Marine	-2.311	-1.320	-3.895	-1.276	2.932 (0.000)	2.737 (0.000)	3.425 (0.002)	2.839 (0.000)
Mutton	-2.479	-1.861	-6.964	-1.807	3.053 (0.000)	2.699 (0.000)	3.456 (0.002)	2.845 (0.000)
Pork	-3.013	-1.164	-2.632	-1.106	2.854 (0.000)	2.720 (0.000)	3.054 (0.022)	2.845 (0.000)
Poultry Chicken	-1.051	-1.207	-5.649	-1.493	**0.810 (0.169)**	**0.742 (0.173)**	**2.501 (0.103)**	**2.033 (0.121)**
G. Condiment & Spices								
Betelnut/Arecanut	**-3.458**[b]	-1.238	-3.786	-1.286	2.099 (0.003)	1.669 (0.018)	**2.720 (0.060)**	2.535 (0.010)
Black Pepper	-2.764	-0.860	-0.342	-0.213	1.601 (0.022)	**1.199 (0.057)**	**2.656 (0.104)**	2.292 (0.045)
Cardamom	-2.018	-1.081	-2.118	-0.982	1.662 (0.021)	**1.139 (0.078)**	3.030 (0.019)	2.469 (0.020)
Chillies (Dry)	-1.960	-1.345	-6.701	-1.825	2.361 (0.000)	2.704 (0.000)	3.043 (0.005)	2.833 (0.000)
Corriander	-2.652	-2.464	-11.42	-2.386	1.433 (0.017)	1.586 (0.013)	2.604 (0.024)	2.411 (0.010)
Cummin	-1.782	-1.661	-5.643	-1.663	**0.851 (0.143)**	**0.873 (0.120)**	**2.596 (0.091)**	**1.981 (0.143)**
Garlic	-2.435	**-2.828**[C]	-7.254	-1.611	1.899 (0.003)	1.831 (0.003)	**2.454 (0.079)**	2.463 (0.005)
Ginger (Dry)	-2.707	-2.276	-9.694	-2.201	0.987 (0.050)	0.392 (0.301)	2.576 (0.021)	2.076 (0.032)
Turmeric	-2.912	**-2.916**[C]	-4.841	-1.536	**1.089 (0.064)**	**0.783 (0.137)**	**2.266 (0.168)**	**1.890 (0.183)**
H. Other Food Article								
Coffee	-2.666	-1.066	-6.537	-1.709	2.898 (0.000)	2.7154 (0.000)	3.215 (0.006)	2.845 (0.000)
Tea	-2.114	-1.958	-6.923	-1.764	1.875 (0.005)	1.3036 (0.040)	2.715 (0.021)	2.718 (0.000)

Note: (1) Superscripts a, b and c denote rejection of the null hypothesis at the 1, 5 and 10% levels of significance, respectively.
Source: Authors' compilations.

5. Conclusions and Policy Implications

In this study, we made an attempt to analyse the stationarity characteristic of prices of 46 agricultural commodities of India covering the period 2000:M1-2013:M1. In doing so, we relied on two batteries of tests. One battery of test is associated with testing the null hypothesis of a unit root whereas; the second battery of test is associated with testing the null hypothesis of stationarity. Results show the robust evidence of stationarity for Betelnut/Arecanut, Black Pepper, Cardamom, Cummin, Garlic, Ginger (Fresh), Guava, Poultry Chicken and Turmeric. This indicates that any policy which influences the prices of these commodities will not have a permanent impact as forecasting of the prices of these commodities would give reliable results due to the nature of stationarity. We recommend the Policymakers/Government not to consider commodity futures ban for these commodities.

While discussing the policy implication, we should also note that there is significant uncertainty as far as trends in agricultural commodities are concerned. Even if the trends exist, it is not for a very long period. Therefore, to reduce the risks associated with the persistence of shocks and price unpredictability, it is suggested that producers should diversify commodity production. However, if Government/Policymakers wish to control food prices, they need to make policies which influence the prices of the commodities exhibiting the unit root behaviour. And any policy shock to the commodities having a unit root will have the permanent impact and Government can also go ahead for commodity futures ban. In our analysis, we found that there are 40 such agricultural commodities, for which Government could take steps for commodity futures ban as very little can be done to forecast their price movements. Moreover, the question of a series' persistence is also very important for modelling strategy, as non-stationary variables require non-standard statistical techniques. In regard to the future research scope, the study may be extended in the direction of analysing the non-linear nature of the series and testing for the nonlinear mean reversion, structural breaks and volatility spill over etc. One may also do the out-of sample forecasting for future policy purposes.

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