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Volatility in agricultural commodity prices is a priority policy agenda in the ongoing debate on commodity markets vis-à-vis food inflation. The extent of volatility in food commodities has been examined by comparing different indicators. In comparison to previous two decades, food prices are volatile globally and more in rice and wheat particularly during the decade since 2000. In contrast, the extent of price volatility in absolute and relative terms for India elucidated that rice and wheat are less volatile. Plausible drivers of price volatility have been empirically verified based on the arguments in economic forums besides elaborating its impact on economy. The study also highlights the various existing price stabilisation measures and concludes with a pragmatic approach of policy interventions to encounter the rising food prices.

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Food Price Volatility in India – Drivers, Impact and Policy Response

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Rationale

Theoretically, volatility refers to an uncertain movement of a random variable over a period of time. Volatility in agricultural commodity prices assumes a lot of significance since its associated uncertainty is one of the major factors affecting the income security of producers and traders threatening the performance of agriculture (World Bank, 1997 and OECD/FAO, 2011) and welfare of the consumers. Hence, volatile agricultural commodity prices in general and food price in particular is a policy priority engaging the attention of economists and policy makers.

Commodities have been guiding and determining the fate and fortune of nations because of the volatility prevailing in their markets (Dasgupta and Chakrabarty, 2009). It has been argued widely that *inter alia*, volatility in agricultural commodity prices originates from the population led and income induced demand increase following years of good economic growth accompanied by changing food habits but not accompanied by commensurate supply, futures trade and globalization. However, volatility in agricultural commodity prices is mainly attributed to supply shocks coupled with the short-run demand and supply elasticity coefficients. Futures market reveals that information on prices, hedging and speculation, and physical transaction influence the volatility in prices. But increasing price volatility has made speculation a common and questioned the utility of futures trading in agricultural commodities. In an arbitrage free economy, asset price in market will rise due to increasing flow of information, thereby, generating the volatility (Mahalik *et al.,* 2009). The WTO led liberalization exposed agriculture to global competition resulting in international price volatility being transmitted to domestic prices (Goleti and Babu, 1994; Dercon, 1995; Alexander and Wyeth, 1994).The above argument merits a detailed empirical analysis in India's story of food price volatility, its impact on the economy and the policy outcome towards its management.

Data and Methodology

The study sourced relevant secondary data from the Food and Agriculture Organisation (FAO); Directorate of Economics and Statistics, Ministry of Agriculture, India; Office of the Economic Adviser, Government of India; indexmundi portal; and National Commodities Derivatives Exchange (NCDEX), Mumbai, India.

Estimation of Instability Index: The magnitude of instability in the prices was measured in relative terms by Cuddy-Della Valle index (Cuddy and Della Valle, 1978) which is used as a measure of variability in time-series data. Simple coefficient of variation overestimates the level of instability in the time series data characterized by the long term trends, whereas Cuddy-Della Valle Index corrects this.

$$\text{Instability Index (\%)} = CV \times \sqrt{(1-\overline{R}^2)}$$

where, CV is the coefficient of variation in percentage and $\overline{R}^2$ is the coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

Estimation of Volatility through GARCH Model: Generalised Autoregressive Conditional Heteroscedasticity (GARCH) has been used to measure the extent of volatility in agricultural commodity prices. This approach distinguishes not only between predictable and unpredictable components of prices but also allows the variance of unpredictable element to be time varying (Bollerslev, 1986). The commonly used GARCH (1,1) model is defined below.

$$Y_{it} = a_0 + b_1 Y_{it-1} + b_2 Y_{it-2} + \varepsilon_{it} \quad \text{.....(1)}$$

where, Y_{it} is the spot price of i^{th} commodity in t^{th} period and t is the time period ranging from 1, 2, 3…n

The variance of the random error is given as $\sigma_{i,t}^2 = \omega + \alpha_i \varepsilon_{i,t}^2 + \beta_i \sigma_{i,t-1}^2$ .....(2)

The conditional variance equation specified in equation (2) is a function of three terms *viz.,* the mean (ω), news about volatility from the previous period measured as the lag of the squared residual from the mean equation (ε_{t-1}^2, the ARCH term) and the last period's forecast variance (σ_{t-1}^2, the GARCH term). The (1,1) in GARCH (1,1) refers to the presence of a first-order GARCH term (the first term in parentheses) and a first-order ARCH term (the second term in parentheses). The sum of (α_i+ β_i) gives the degree of persistence of volatility in the price series. Closer the sum to one, greater is the tendency of price volatility to persist for long time. If the sum exceeds one, it indicates an explosive time series with a tendency to meander away from mean value. The mean term (ω) given in equation (2) is written as a function of exogenous variables with an error term. Since σ_t^2 is the one-period ahead forecast variance based on past information, it is called the conditional variance.

An ordinary ARCH model is a special case of a GARCH specification in which there are no lagged forecast variances in the conditional variance equation. Higher order GARCH models, denoted by GARCH (*p, q*), can be estimated by choosing either *p* or *q* or both greater than one. The representation of the GARCH (*p, q*) is given as,

$$\sigma_{i,t}^2 = \omega + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2$$

where, *p* is the order of the GARCH terms and *q* is the order of the ARCH term.

After fitting the model, it was tested for ARCH-LM to identify whether the fitted model has any further ARCH effect. ARCH-LM is the test for identifying the presence of serial correlation in the residuals. The best fitted model with no further ARCH effects was presented and discussed further. For the present study, EVIEWS7 software has been used for GARCH estimation.

Price Transmission and Market Integration: Several studies have tested integration between markets with subsequent improvement in the methodology (Hendry and Anderson, 1977; Engle and Granger, 1987; Johansen, 1988, 1991, 1994 and 1995; and Goodwin and Schroeder, 1991). The present study has utilised the Johansen's cointegration approach to explore the cointegration possibility between selected markets. The test relies heavily on the relationship between the rank of a matrix and its characteristic roots. Kumar and Sharma (2003) recognized the superiority of Johansen's technique owing to its computational ease, robustness *sans apriori* assumptions on endogenity or exogenity of variables and simultaneity in test and number of cointegration relationships unimposed beforehand. The formulation is as follows:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \alpha \beta' Y_{t-k} + \varepsilon_t$$

where, Y_t is the price time series, Δ is the first difference operator ($Y_t - Y_{t-1}$) and matrix $\Pi = \alpha\beta'$ is (n x n) with rank r ($0 \leq r \leq n$), which is the number of linear independent cointegration relations in the vector space of matrix. Here, α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients. The Johansen's method of cointegrated system is a restricted maximum likelihood method with rank restriction on matrix $\Pi = \alpha\beta'$. The rank of Π can be determined by λ_{trace} test statistic and is given by,

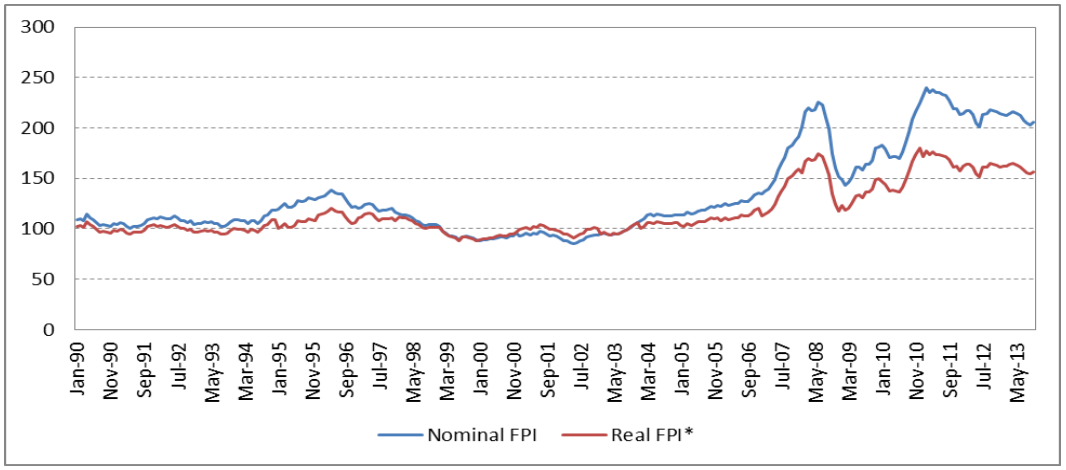
$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$, for r = 0, 1,…, n-1

where, $\hat{\lambda}_i$'s are the Eigen values (estimated values of the characteristic roots obtained from the estimated Π matrix) representing the strength of the correlation between the first difference part and the error-correction part, and T is the number of usable observations. The following hypotheses can be tested, H_0: rank of Π = r (null hypothesis), and H_1: rank of Π> r (alternate hypothesis), where 'r' is the number of cointegration equations. Prior to testing for cointegration, the presence and the order of stationarity were checked by performing the Augmented Dickey-Fuller (ADF) test. The test was conducted on the variables in level (original price series) and their first differences (Dickey and Fuller, 1979). Since the test is sensitive to lag length, the appropriate lag distribution was decided by choosing a specification minimising the Schwarz Information Criterion (SIC), derived from the principles of information.

Trends in food price volatility

Global scenario: Food Price Index (FFPI) introduced in 1996 by the FAO and extended back to 1960 has been utilised to capture the volatility in the global agricultural commodity markets (Figure 1). It should be noted that there is a clear distinction between price level and price volatility (Bellemare, 2014). Long term trend of both nominal and real prices indicated no evidence of volatility in agricultural commodity prices internationally (FAO). However, it has been higher during the decade since 2000 in comparison to the previous decades. During the significant price hikes in 2008, the FFPI gained prominence as an indicator of potential food security concerns for vulnerable developing countries barring 2009 and 2010 when prices of agricultural commodities have remained at relatively high levels. Cereals followed a similar pattern (Figure 2 and 3) in the most recent years (2006-2010) corroborating the findings of Huchet (2011). There is no significant change in the behaviour of monthly price indices between series with sugar exhibiting the maximum volatility and periods of high and volatile prices are often followed by long periods of relatively low and stable prices. It is well established that agricultural markets are intrinsically subjected to high price variation.

Indian scenario: Surplus production in staple food commodities and the reduced trade deficit helped higher agricultural growth but spurred inflation sharply. Inflation measured in Wholesale Price Index (WPI) comprising more than 600 goods of which primary articles, fuel and lubricants, and manufactured goods accounted for a weight of 20.12 per cent, 14.91 per cent and 64.97 per cent respectively. Primary articles comprise the food (14.34 %), non-food (4.26 %) and minerals items (1.52 %). Among food items, foodgrains has the more weight (4.09 %), followed by fruits and vegetables (3.84 %), milk (3.24 %), eggs, meat and fish (2.41 %), condiments and spices (0.60 per cent) and other items like tea and coffee (0.18 %). Milk has the highest weight (3.24 %), followed by rice (1.79 %) and wheat (1.12%). The WPI is calculated weekly and each commodity has its own weight and contributes to the inflation/deflation based on the price quotations collected from different markets across the country.



Note: * is the real price index which is the nominal price index deflated by the World Bank Manufactures Unit Value Index

Figure 1. Annual FAO food price indices with 2002-04 as a base period

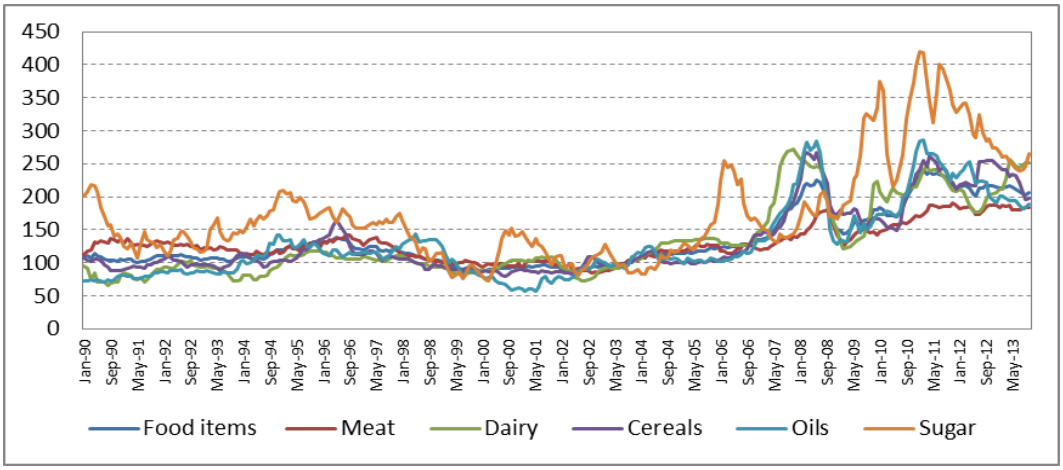


Figure 2. Monthly commodity price indices with 2002-04 as a base period

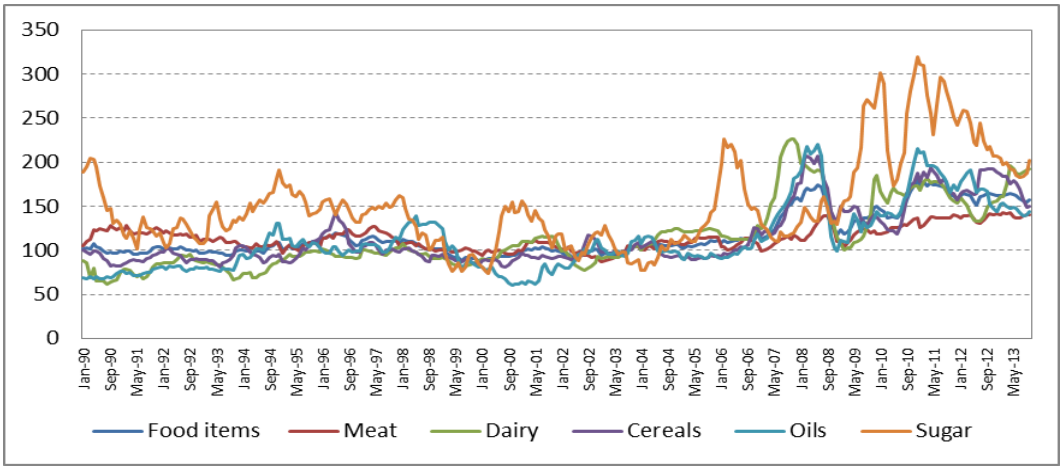


Figure 3. Deflated monthly commodity price indices with 2002-04 as a base period

Price increase of rice and wheat erodes the real incomes of the poor owing to the significant share in their consumption expenditure. The rate of inflation often leverages on one or other food items as in 2010 (Figure 4) and that continued in 2011 to 2013 (Figure 5). Inflation for food articles and food products reached double digits in April 2009 and went beyond 20 per cent in December (Chand, 2010). The volatility seems to be more in condiments and spices, followed by vegetables and eggs, meat and fish with a consistent increase in the index of overall food items.

The variation in WPI ranged from 14.30 per cent in ginger to as high as 63.33 per cent in turmeric indicating the wide range among spices and condiments. Skewness and kurtosis confirms fat tails and scattered observations common to agricultural price data. Barring wheat, black gram and chilly, the rest skewed positive and platykurtic indicating that the probability of extreme WPI is less, and they are widely spread around its mean.

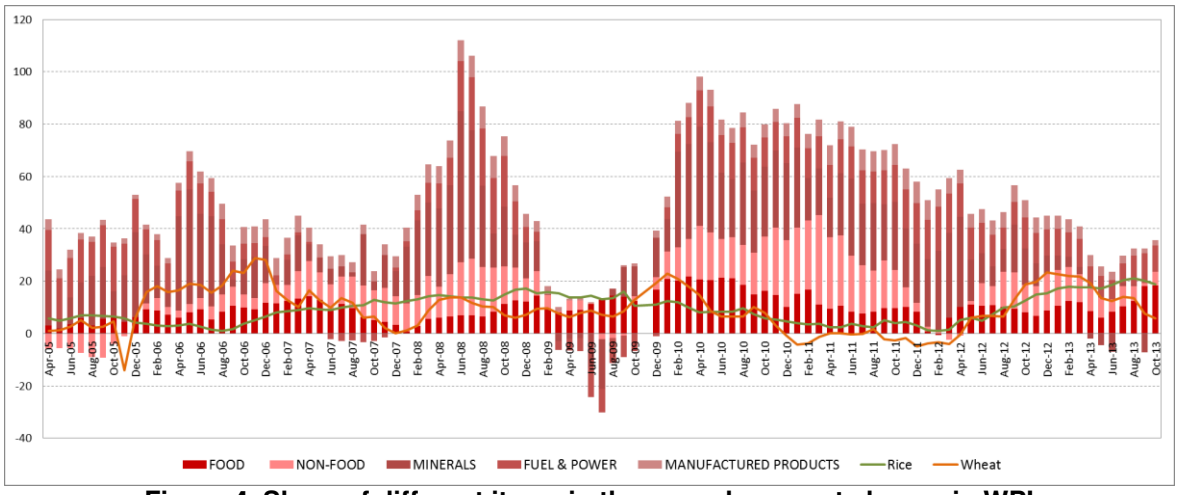


Figure 4. Share of different items in the annual per cent change in WPI

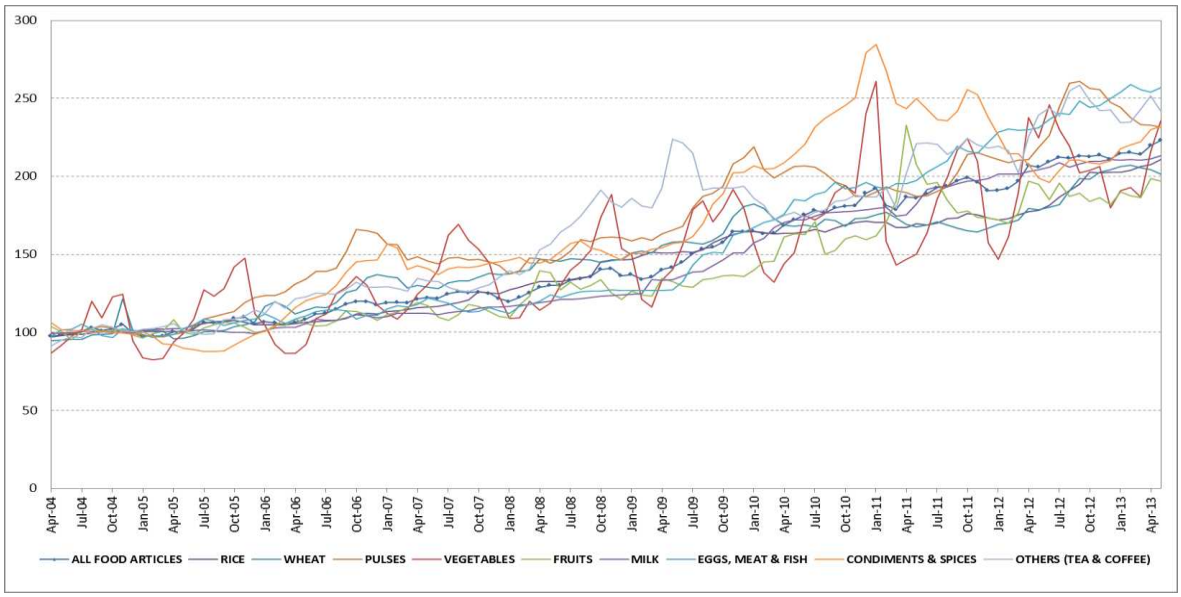


Figure 5. Trends in the monthly WPI for food articles

Onion, recently in the news for soaring prices to the extent of 600 per cent, registered the maximum kurtosis (7.12). While consumers suffered, producers lost the standing crop due to untimely rains sold at throwaway prices (Sendhil, 2012). Surging prices of all commodities but edible oils, at the rate a consumer on an average has to incur an additional expenditure of 20 per cent on food items to maintain their level of consumption (Chand, 2010). He also postulated that supply shock owing to drought in 2009 and the carry-over effect of the low growth in food production during 2008-09 were the main reasons for the food inflation in 2010. The extent of volatility captured through Generalised Autoregressive Conditional Heteroscedasticity (GARCH) showed that foodgrains have the lowest coefficient (0.094618), despite persistent volatility in pulses. Rice and wheat individually exhibit less volatility. Estimates of GARCH in vegetables and eggs, meat and fish indicated that the volatility will persist for longer time. Unlike international market, less volatility prevailed in domestic prices of rice and wheat. *Inter alia,* Public Distribution System (PDS) and trade policy instruments during global food crisis have stabilized the prices (Dasgupta et al., 2011).

Table 1. Estimated statistics for the monthly WPI (Apr-04 to May-13) for different food articles

Commodities	Weight in WPI	Skewness	Kurtosis	Max	Min	CV (%)	Cuddy-Della Valle index (%)	GARCH estimate
A. Foodgrains (cereals + pulses)	4.08982	0.21	-1.05	216.90	96.70	23.86	3.71	0.094618
A1. Cereals	3.37323	0.23	-1.06	213.80	96.00	23.34	3.56	-0.278263
Rice	1.79348	0.25	-1.17	210.90	96.90	23.36	4.34	0.545192
Wheat	1.11595	-0.05	-0.97	207.20	94.80	21.70	5.25	-0.377022
Jowar	0.09572	0.46	-1.02	261.70	93.40	30.87	8.69	0.221241
Bajra	0.11522	0.73	-0.25	264.20	94.50	28.61	8.13	1.029931
Maize	0.21727	0.76	-0.54	251.00	95.00	28.61	8.56	0.917755
Barley	0.01671	0.28	-0.72	217.70	90.00	22.58	5.87	0.527152
Ragi	0.01885	1.33	1.41	349.60	96.70	39.22	17.15	0.892935
A2. Pulses	0.71662	0.15	-0.86	260.80	97.10	26.78	7.80	0.962145
Gram	0.33490	1.15	0.94	294.00	97.40	30.13	17.00	0.872939
Arhar	0.13740	0.23	-1.33	262.70	88.50	30.56	15.27	0.888745
Moong	0.08429	0.32	-1.28	327.20	97.10	35.54	17.40	0.824364
Masur	0.05764	0.03	-1.27	252.00	92.80	28.35	18.29	-0.79592
Urad	0.10239	-0.04	-1.01	294.90	94.70	29.34	16.92	0.894618
B. Fruits and vegetables	3.84270	0.40	-1.06	215.30	90.50	24.99	8.71	0.752387
B1. Vegetables	1.73553	0.47	-0.51	261.10	82.60	28.34	15.78	0.983543
Potato	0.20150	1.29	1.46	303.60	72.00	33.71	30.13	0.039235
Sweet potato	0.01750	0.47	-0.11	277.00	76.80	28.79	19.16	0.448599
Onion	0.17794	1.98	7.12	619.40	75.00	47.21	38.63	0.454374
Tapioca	0.06781	0.69	-0.43	444.60	85.30	47.25	20.77	1.014113
Ginger(fresh)	0.04514	0.78	1.11	209.30	37.20	36.74	35.50	0.726682
Peas(green)	0.10999	1.47	2.31	312.70	62.10	40.65	36.09	NE
Tomato	0.26738	0.86	0.22	276.90	62.00	35.45	30.85	NE
Cauliflower	0.23627	0.62	-0.19	210.50	68.90	28.40	22.72	NE
Brinjal	0.29840	0.50	-0.15	239.70	81.70	24.94	15.20	0.741772
Okra (lady finger)	0.12604	1.27	1.38	356.40	71.60	39.45	24.08	0.795716
Cabbage	0.18756	1.35	2.70	447.10	54.20	44.96	35.66	0.726949
B2. Fruits	2.10717	0.62	-0.87	232.70	95.50	24.96	9.00	0.58992
Banana	0.34264	0.79	-0.33	229.00	92.80	25.27	8.69	0.980005
Mango	0.65134	0.74	0.00	310.60	84.30	35.85	17.07	NE
Apple	0.10397	0.53	-0.85	283.10	82.80	33.47	13.25	NE
Orange	0.13309	0.68	-0.90	251.20	76.70	32.04	13.80	0.512577
Cashew nut	0.16399	0.76	-0.93	210.10	90.10	26.38	11.33	0.191892
Coconut (fresh)	0.24113	0.80	-0.16	134.20	73.80	15.52	12.34	0.903254
Papaya	0.10340	1.14	1.08	281.40	81.60	31.89	23.88	1.007669
Grapes	0.09399	0.80	-0.78	247.40	82.40	31.76	16.11	NE
Pineapple	0.04577	0.61	-0.80	259.90	81.30	34.00	12.75	0.963649
Guava	0.07609	1.82	3.97	265.60	75.50	28.45	28.13	0.555759
Litchi	0.03716	0.82	-0.45	179.20	77.10	32.74	26.09	NE
Lemon	0.07225	1.08	1.88	395.80	79.90	34.28	28.33	-0.945748
Sapota	0.04235	0.77	-0.55	282.20	84.90	34.74	15.38	-0.231348
C. Milk	3.23818	0.51	-1.36	213.20	99.10	28.40	8.02	0.55911
D. Eggs, meat and fish	2.41384	0.70	-1.01	258.90	96.50	33.93	11.36	0.968185
Egg	0.18675	0.42	-1.20	204.80	84.40	25.76	7.56	0.701626
Fish-inland	0.57256	0.99	-0.46	332.00	96.30	46.85	23.64	0.495568
Fish-marine	0.72259	0.57	-1.17	294.80	88.30	38.20	12.35	1.108179
Mutton	0.34586	0.30	-1.40	237.30	97.00	28.47	6.31	0.878472
Beef & buffalo meat	0.11585	0.46	-1.62	207.70	92.90	27.51	10.65	-0.747939
Poultry chicken	0.41028	0.73	-0.31	184.80	83.70	19.05	9.11	1.323772
Pork	0.05995	0.22	-1.16	247.10	99.60	29.07	5.65	0.903828
E. Condiments and spices	0.56908	0.21	-1.13	284.60	87.60	32.23	13.55	0.622618
Black pepper	0.02959	1.05	-0.23	538.90	86.10	60.87	26.73	0.738124
Chillies (dry)	0.15812	-0.10	-0.81	295.60	70.90	33.71	13.55	0.626629
Turmeric	0.07573	1.45	0.97	458.60	78.00	63.33	51.76	1.068371
Cardamom	0.01703	0.56	-1.08	409.80	71.00	51.60	26.82	0.917308
Ginger (dry)	0.05150	0.17	-0.66	126.90	70.30	14.31	14.20	-0.973841
Betelnut/ Arecanut	0.10437	0.74	-0.50	240.00	95.70	26.99	11.24	0.920868
Cummin	0.04393	0.34	-1.32	210.90	92.70	25.46	7.46	0.204501
Garlic	0.06437	1.69	3.57	646.30	70.80	58.35	54.09	0.59683
Corriander	0.02444	0.78	0.55	389.50	89.40	36.95	30.26	0.266416
F. Other food articles	0.18347	0.15	-1.27	258.30	91.40	29.47	8.09	0.496682
Tea	0.11233	0.43	-0.91	222.60	81.50	28.37	15.23	0.971317
Coffee	0.07114	0.19	-0.88	353.10	81.60	33.97	8.81	0.426825

Note: NE indicates the non-estimation of the GARCH model due to a lot of missing observations.

Inflation vis-à-vis WPI

India has adopted the WPI as an indicator for inflation for a variety of reasons, such as vast coverage of commodities and high frequency data (Figure 6). On the downside, it does not measure the exact price rise faced by the consumers, but captures the impact of price rise on businesses. Further, the spending power has shifted towards expanding urban middle class, whose expenditure on food articles has been declining even as the consumption of non-food, manufacturing items and expenditure towards health, education, transport, communication and entertainment has been increasing in rural India. Surprisingly, commodity weightage in WPI is based on the gross value of output only. However, there are four different consumer price indices (CPI) covering different population groups and hence cannot be considered as a norm for a national level unified index (Appendix 1). In the recent years there is an evidence of divergence between WPI and the CPI complicating the impact of monetary policy. Consumer Price Index (CPI) is the official barometer for estimating inflation in many countries including US, UK, Japan, France, Singapore and China. It is a proxy to the cost of living index and captures the cost of goods consumed by the people of a country.

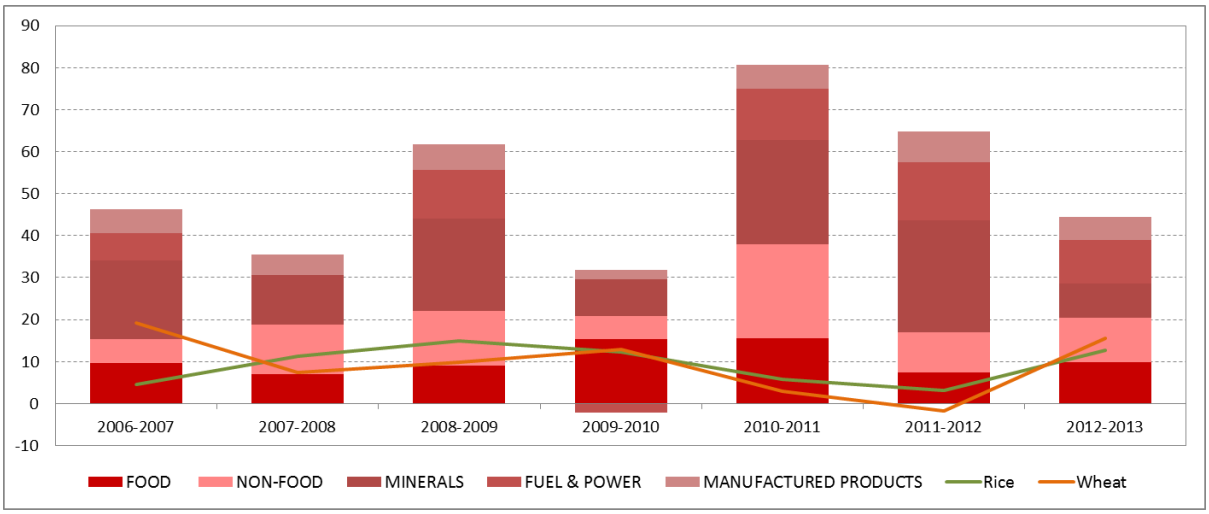


Figure 6. Share of different items in inflation

The other measures that are widely used as a measure of inflation are producer price index, core price index and GDP deflator. India aims to adopt the producer price index (PPI) in place of WPI, the existing indicator of inflation in the country. PPI is the index of all transactions in manufacturing and agriculture at the first point of sale. It helps to compare the average change in selling price of a country's domestic output over a period of time. The service sector that contributes more than 50 per cent of the GDP of the country will also be included in the PPI. The computation of PPI will help in looking at the margins (logistics, taxes and other levies). The PPI will help to measure the economy's efficiency in transferring goods and services from producers to the consumers. The cost pressure on the economy is also reflected in the producer price index. The immediate priorities should consist of (i) constructing an internationally acceptable and comparable price index series, (ii) benchmarking the goal of monetary policy towards inflation, (iii) restructuring the weights owing to the changing consumption expenditure patterns, and (iv) adopting the expectation surveys in developing appropriate policy perspectives.

Sources/ Drivers of Volatility in Food Prices

Understanding the key trends in production, domestic marketing, international trade and economic policies shall guide us to track the food price volatility. *Inter alia,* short-run demand and supply elasticity coefficients, climate change, yield fatigue, surplus/shortage in production, globalization, economic boom/depression, futures markets, population growth,

changing dietary preference and increasing demand for processed foods play a major role in price determination. Concerted and coherent efforts have been made in this section to capture the possible sources/drivers of food price volatility in Indian economy:

1. Interstate variation in production vis-à-vis instability in WPI: The authors have tried to establish the fact that interstate variations in production influence the domestic prices. However, total output of a commodity in a particular year has more influence in price determination than the previous hypothesis. Table 1 and 2 respectively shows the interstate variations in food articles and instability in monthly WPI. Despite a few less perishable commodities like wheat, barley and bajra, the interstate variation in production in rest of the food articles follows a similar kind of pattern. On the contrary, highly perishable commodities like fruits and vegetables exhibited a high variation in production among states. Though the correlation results (Table 3) do not provide any concrete evidences as to the driving forces behind price volatility, individual crop figures indicate some propositions. For instance, interstate variation in production and instability in price indices was lowest in wheat in 2007-08. Similarly, a year with high variation in production among states follows low price instability in the subsequent year. One more interesting cyclical pattern observed was that a rise in production instability is either followed by one or two years with a fall in production variation especially in rice and wheat (Table 1).

2. Futures trading vis-à-vis instability in WPI: Global food crisis and food inflation in India during 2008-09 led the critiques to blame it on the futures trading and suspect the sustainability of economic growth process and efficiency of public management system in containing the same. One of the basic functions of the futures market is to stabilise the commodity prices. But the issue over the past two decades is that, food prices are more volatile than any other commodity (Chand, 2010). The government took several policy measures during 2006-2011 to ward-off the adverse impact of global food crisis particularly in rice and wheat (for details refer Acharya et al., 2012).

A perusal of the profile of agricultural commodities traded in 2013 reveals that over years, the number of agricultural commodities has reduced in general and food articles in particular (Table 4). In 2007, a ban was imposed to trade certain commodities like rice, wheat, pigeonpea and blackgram (Table 5). On May, 2008, Indian Government reimposed the ban on futures trading in four agricultural commodities viz., chickpea, potato, rubber and soy oil. Subsequently in May, 2009 sugar was banned from trading. However, barring rice, pigeon pea and black gram rest of the commodities have been relisted for trading. Listing, delisting and relisting the commodities on exchanges indicated the vacillations of the state in wielding the policy instrument effectively in the context of price volatility. The Abhijit Sen Committee examined the impact of futures trading on food inflation and gave an inconclusive decision on the cause and effect relationship between futures and spot prices. Srinivasan (2008) also corroborated by stating that the exact impact of futures trading on rising food prices is not established. The controversy is still a debate among the academicians, researchers and policy makers, and most of their research could not find any strong evidence of futures trading against the rising food prices. With futures being blamed for price volatility, the present section brings out some empirical evidences on price behaviour after the inception of agricultural commodity futures.

Among the selected commodities, the ban is being continued for rice, pigeon pea and black gram despite the evidence of high volatility during the ban period in comparison to pre-ban (Table 6). In the rest of the food articles, futures influenced the level of price volatility in different magnitude. However, prices of non-food commodities like rubber and sugar rather stabilized by futures.

Table 2. Interstate variation in production for different food articles (in per cent)

Commodities	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
A. Foodgrains (cereals + pulses)	141.06	141.03	137.98	136.08	142.67	143.07	140.38	139.17	NA
A1. Cereals	142.8	142.9	140.4	138.8	145.3	146.0	143.5	141.0	NA
Rice	147.7	142.6	141.7	142.1	145.4	144.4	143.3	136.4	NA
Wheat	130.04	135.28	119.06	117.59	124.00	120.74	121.73	161.02	163.94
Jowar	232.5	240.6	241.8	245.6	240.6	254.6	231.4	198.8	NA
Bajra	187.7	174.9	197.4	207.6	229.8	175.4	213.5	204.4	NA
Maize	140.1	155.4	140.7	146.6	146.9	141.7	154.6	141.6	NA
Barley	180.19	197.57	199.98	198.79	216.55	193.42	233.28	200.91	NA
Ragi	307.2	315.8	247.1	300.3	295.5	300.3	312.7	278.5	NA
A2. Pulses	198.2	191.4	183.9	177.2	188.8	206.9	183.9	189.5	NA
Gram	231.5	218.6	203.5	182.9	207.4	227.0	192.2	218.1	NA
Arhar	172.1	177.2	197.1	200.2	170.2	205.1	199.8	191.0	NA
B. Fruits and vegetables									
B1. Vegetables									
Potato	251.4	221.8	227.5	235.7	212.6	217.9	213.4	214.7	215.8
Onion	164.8	183.3	192.7	221.7	217.9	193.9	173.7	174.2	157.5
Tapioca	194.1	194.4	211.1	219.4	210.7	199.0	237.4	225.1	NA
Okra (lady finger)	83.7	79.8	87.2	56.5	60.3	57.0	63.1	70.4	NA
Cabbage	NA	NA	NA	155.4	141.1	136.9	129.7	144.6	143.0
B2. Fruits									
Banana	89.6	90.4	83.9	83.5	78.9	71.6	81.1	162.8	169.3
Apple	134.9	114.5	136.6	114.0	159.8	181.8	138.8	171.0	185.2
Orange	169.8	170.2	150.8	153.1	122.4	107.4	104.4	118.8	127.5
Papaya	101.4	128.3	105.1	128.8	205.4	196.8	92.0	156.6	156.4
Grapes	244.7	247.9	245.1	254.0	267.1	200.1	160.5	254.3	260.9
Guava	46.5	40.7	47.3	39.1	56.8	53.9	41.9	39.6	92.3
Litchi	201.2	192.4	180.0	171.5	181.3	166.4	132.5	182.7	186.1
Lemon	122.6	125.1	84.4	104.7	90.0	88.0	85.5	82.4	151.1
Sapota	107.9	107.3	107.5	108.2	131.3	143.4	82.7	152.6	152.6
C. Milk	NA	NA	NA	139.9	140.0	140.1	140.2	141.2	NA
D. Eggs, meat and fish									
Egg	NA	NA	NA	219.9	220.8	220.5	220.4	NA	NA
Fish-inland	203.8	200.7	203.8	205.3	202.4	200.0	201.8	NA	NA
Fish-marine	192.3	196.8	97.4	194.3	186.8	188.5	185.4	NA	NA
E. Condiments and spices									
Black pepper	200.3	140.2	142.5	NA	NA	NA	NA	267.4	267.4
Betelnut/ Arecanut	180.0	189.8	186.1	189.9	184.4	184.1	184.1	207.8	208.3

Note: NA indicates non-availability of the data.

Table 3. Volatility in monthly wholesale price indices for different food articles

Commodities	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Correlation*
A. Foodgrains (cereals + pulses)	1.85	0.76	2.72	0.88	0.51	2.84	0.56	0.88	1.49	0.09
A1. Cereals	2.22	1.03	1.82	0.75	0.73	2.50	0.72	1.20	1.32	0.27
Rice	0.45	0.92	0.59	1.09	1.96	1.75	1.19	1.22	1.51	-0.01
Wheat	7.21	3.53	4.61	1.19	1.29	4.76	1.91	2.21	2.60	-0.12
Jowar	3.49	4.75	4.33	0.75	3.66	1.71	5.03	2.23	2.56	-0.05
Bajra	1.54	1.47	1.70	1.78	2.58	2.44	3.77	3.23	2.94	0.50
Maize	3.17	1.55	2.56	2.18	0.97	1.04	3.54	3.62	1.76	-0.10
Barley	4.35	4.96	2.48	3.67	0.99	0.65	4.55	4.71	2.81	-0.02
Ragi	1.33	0.92	1.77	1.32	4.62	0.76	2.14	1.22	4.36	-0.07
A2. Pulses	2.22	1.40	6.49	2.48	2.64	4.49	2.09	2.99	2.53	0.08
Gram	1.79	1.99	10.33	2.28	1.74	2.47	1.99	5.05	4.05	-0.10
Arhar	4.89	2.95	2.49	2.04	6.36	5.99	5.04	1.94	3.59	-0.24
Moong	2.51	3.23	3.81	3.63	4.36	5.47	6.00	1.83	1.34	NE
Masur	2.48	2.43	5.03	4.92	3.77	5.53	2.18	2.47	2.41	NE
Urad	2.57	4.57	6.27	5.18	2.71	6.77	4.20	2.03	2.42	NE
B. Fruits and vegetables	6.97	6.49	4.52	7.02	7.94	5.39	7.65	9.72	7.11	NE
B1. Vegetables	13.93	13.60	8.64	10.19	15.08	10.10	19.91	16.34	13.65	-0.14
Potato	20.58	11.85	23.66	9.63	25.68	24.39	13.74	25.21	15.17	-0.18
Sweet potato	12.38	19.07	13.99	11.98	5.36	11.41	12.39	11.07	6.23	NE
Onion	5.41	37.12	18.72	22.76	17.02	25.48	58.58	15.22	17.73	-0.03
Tapioca	4.76	5.48	6.52	4.49	2.98	10.55	9.27	8.34	8.25	0.29
Ginger(fresh)	22.84	14.38	10.20	15.41	19.13	19.29	13.56	12.94	27.85	NE
Peas(green)	27.89	13.96	19.89	11.76	11.00	16.31	16.27	26.35	17.93	NE
Tomato	15.33	16.53	13.35	20.45	34.76	20.82	27.95	35.03	14.90	NE
Cauliflower	8.16	13.22	10.71	12.16	8.27	9.50	17.88	9.34	8.60	NE
Brinjal	15.20	18.02	6.87	12.18	14.98	9.01	21.36	11.88	17.07	NE
Okra (lady finger)	19.92	17.90	12.30	11.52	11.41	16.30	25.77	20.70	19.24	0.10
Cabbage	33.15	17.17	21.09	20.65	33.09	23.47	21.13	27.79	32.67	0.03
B2. Fruits	2.99	2.35	3.11	6.09	3.47	3.23	9.76	5.64	2.78	NE
Banana	5.45	4.58	2.74	3.63	2.77	5.35	6.73	7.11	3.80	0.24
Mango	11.53	5.68	5.11	13.39	2.63	1.69	21.94	7.61	7.12	NE
Apple	5.73	3.65	2.69	8.98	2.73	3.94	4.06	4.15	2.38	-0.55
Orange	2.48	9.54	6.50	9.17	2.71	3.30	6.68	2.59	7.20	0.37
Cashew nut	2.92	4.59	2.80	2.32	4.93	4.83	3.93	5.15	2.53	NE
Coconut (fresh)	3.60	5.47	4.16	3.52	2.32	2.76	2.94	2.20	6.69	NE
Papaya	9.87	3.99	8.96	8.27	13.05	13.00	11.01	16.76	14.16	0.51
Grapes	8.54	3.05	1.96	4.98	6.46	1.62	8.79	8.32	10.52	0.05
Pineapple	7.39	9.00	7.24	10.42	9.51	8.37	7.37	6.58	8.04	NE
Guava	7.22	8.81	10.36	11.74	19.12	20.00	18.75	19.44	15.00	0.16
Lemon	16.34	26.84	24.12	23.60	12.63	0.00	20.55	21.83	21.47	0.28
Sapota	8.44	8.47	7.97	14.11	6.96	8.09	7.98	10.62	10.59	0.14
C. Milk	0.38	1.79	0.84	0.38	1.79	1.26	2.18	0.37	0.51	-0.41
D. Eggs, meat and fish	3.11	2.00	2.54	2.64	3.06	1.45	1.29	1.44	1.26	NE
Egg	4.83	7.93	2.38	1.64	2.01	7.23	4.03	3.87	2.64	0.25
Fish-inland	2.09	3.52	2.33	1.34	11.90	3.26	5.85	5.81	2.30	-0.28
Fish-marine	9.73	4.73	7.88	7.39	0.03	5.32	4.05	4.69	2.39	-0.26
Mutton	1.45	1.98	0.84	1.07	4.70	4.51	1.93	0.84	0.59	NE
Poultry chicken	7.16	6.12	7.88	2.29	0.00	3.30	4.08	5.70	7.92	NE
Pork	1.78	1.22	6.00	0.27	0.00	1.67	1.68	2.20	0.84	NE
E. Condiments and spices	2.18	2.59	6.13	1.26	2.70	3.48	6.70	4.88	1.64	NE
Black pepper	3.15	3.96	6.97	2.79	5.34	3.26	4.27	3.86	2.07	-0.67
Chillies (dry)	5.34	10.07	7.59	4.43	5.22	1.90	8.30	5.28	3.47	NE
Turmeric	2.54	2.28	3.29	3.59	6.15	7.85	11.58	6.43	5.39	NE
Cardamom	3.98	5.78	5.55	5.66	8.89	7.36	9.21	5.63	2.50	NE
Ginger (dry)	3.81	8.35	5.53	4.79	2.03	6.69	3.25	3.03	5.05	NE
Betelnut/ Arecanut	1.93	5.81	3.25	1.38	2.63	1.10	5.02	4.12	2.86	0.21
Cummin	2.79	2.72	2.83	5.23	3.35	5.77	2.05	2.10	4.11	NE
Garlic	7.78	7.89	20.35	14.01	13.65	15.06	32.45	27.36	21.01	NE
Corriander	12.69	8.98	6.54	9.93	5.43	8.80	8.55	4.86	5.42	NE
F. Other food articles	2.42	2.13	1.86	3.62	6.05	3.21	4.83	4.55	3.03	NE
Tea	4.95	3.93	4.83	5.82	9.39	6.92	4.18	10.58	3.21	NE
Coffee	4.23	5.48	3.89	2.20	2.55	2.67	7.61	3.83	4.37	NE

Note: * indicates the correlation between interstate variation in production and price index instability for available data and NE: Not estimated.

Table 4. Profile of agricultural commodities traded in 2013 in Indian futures market

S.No.	Commodity(Scientific name)	Futures trading started from (DD.MM.YY)	Weight in WPI
1.	Chickpea(*Cicer arietinum*)	12.04.2004	0.33490
2.	Wheat (*Triticum aestivum*)	06.07.2004	1.11595
3.	Maize (*Zea mays*)	05.01.2005	0.21727
4.	Potato (*Solanum tuberosum*)	07.07.2006	0.20150
5.	Barley(*Hordeum vulgare*)	11.12.2006	0.01671
7.	Soybean (*Glycine max*)	15.12.2003	0.37111
8.	Mustard seed (*Brassica nigra*)	15.12.2003	0.33797
9.	Cotton seed oilcake (*Gossypium spp*)	05.04.2005	0.12928
10.	Castor seed (*Ricinus communis*)	23.07.2004	0.04425
11.	Crude palm oil (*Elaeis guineensis*)	15.12.2003	0.41999
12.	Turmeric (*Curcuma longa*)	27.07.2004	0.07573
13.	Cumin or Jeera(*Cuminum cyminum*)	03.02.2005	0.04393
14.	Pepper (*Piper nigrum*)	12.04.2004	0.02959
15.	Chilli (*Capsicum annum*)	11.03.2005	0.15812
16.	Guar seed (*Cyamopsis tetragonoloba*)	12.04.2004	0.04830
17.	Guar gum (*Cyamopsis tetragonoloba*)	26.07.2004	Not included
18.	Gur or Jaggery(*Saccharum officinarum*)	05.01.2005	0.07763
19.	Kapas (*Gossypium spp.*)	04.10.2005	Not included
20.	Sugar (*Saccharum officinarum*)	27.07.2004	1.73731
21.	Cotton (*Gossypium spp.*)	07.08.2006	0.70488
22.	Rubber (*Hevea brasiliensis*)	12.04.2004	0.16446
23.	Refined soy oil(*Glycine max*)	15.12.2003	0.37971
24.	Soybean meal (*Glycine max*)	23.08.2004	0.05937
25.	Coriander (*Coriandrum sativum*)	11.08.2008	0.02444

Note: The information were collected and compiled from NCDEX and Office of the Economic Adviser, India.

Table 5. Profile of selected banned agricultural commodities in Indian futures market

S.No.	Commodity	Inception	Suspension/Ban time	Trading revival
1.	Rice	January, 2005	February, 2007	Ban continues
2.	Wheat	July, 2004	February, 2007	May, 2009
3.	Sugar	July, 2004	May, 2009	December, 2010
4.	Pigeon pea	NA (taken as April, 2004)	January, 2007	Ban continues
5.	Black gram	July, 2004	January, 2007	Ban continues
6.	Soy oil	December, 2003	May, 2008	December, 2008
7.	Rubber	March, 2004	May, 2008	December, 2008
8.	Chickpea	March, 2004	May, 2008	December, 2008
9.	Potato	July, 2007	May, 2008	December, 2008
10.	Guar gum	July, 2004	March, 2012	May, 2013
11.	Guar seed	April, 2004	March, 2012	May, 2013

Note: The information were collected and compiled from the circulars of NCDEX portal.

Table 6. Extent of volatility across commodities before, during and lifting ban on futures

Commodity	CV (%)			Cuddy-Della Valle index (%)		
	Pre-ban	Ban	Trading revival	Pre-ban	Ban	Trading revival
Rice	3.31	17.34	Ban continues	1.50	4.34	Ban continues
Wheat	11.94	5.61	8.93	6.45	1.51	5.22
Sugar	9.76	10.15	6.51	9.74	10.44	3.93
Pigeon pea	6.47	20.43	Ban continues	6.11	14.69	Ban continues
Black gram	27.90	20.48	Ban continues	8.20	16.08	Ban continues
Soy oil	11.33	2.14	13.35	7.54	1.48	4.83
Rubber	23.77	21.66	27.18	11.18	16.21	21.16
Chickpea	19.98	1.61	25.61	11.03	1.44	15.24
Potato	21.35	7.01	33.42	9.54	2.76	32.75
Guar seed	74.26	35.58	15.43	63.22	29.38	13.68

Note: Monthly WPI were used based on the information from Table 6.

3. Price transmission between domestic and international market

During 1990s, the economic liberalisation in many countries exposed food prices to domestic and international market forces (UNCTAD, 1997; World Bank, 1997). Globalisation vis-à-vis domestic food price volatility arguments apart, climate change, depleting stocks and strategic reserves, speculation in futures, diversion of grains for ethanol production and rise in oil prices have their respective role in increasing volatility. A significant increase in oil prices directly impacts the cost of fertilizers and thereby raising the food prices. About 205 per cent increase in oil prices (real terms) in the international market has been noticed between 2005 and 2008 (Acharya et al., 2012). To identify the impact of globalisation on food price volatility, we have selected three major foodgrains *viz.,* rice, wheat and maize which are globally traded. Relevant data were collected from the FAO (domestic prices) and IMF (international prices) and tested for price integration between the domestic and international market for pre-WTO, post-WTO and overall period. There was a lack of convergence between the domestic and international prices of the selected commodities (Figures 7 to 9).

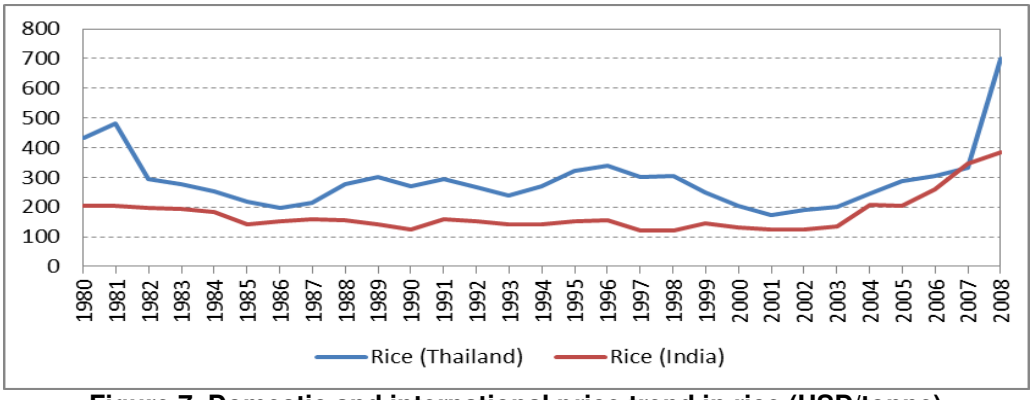


Figure 7. Domestic and international price trend in rice (USD/tonne)

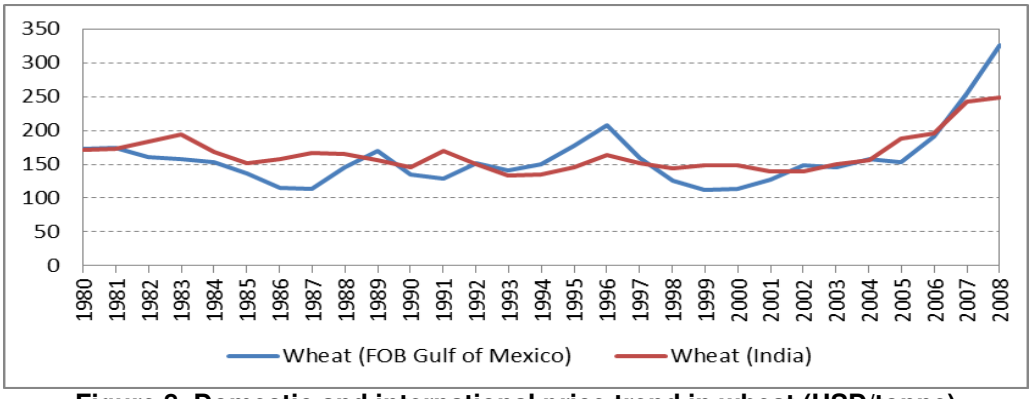


Figure 8. Domestic and international price trend in wheat (USD/tonne)

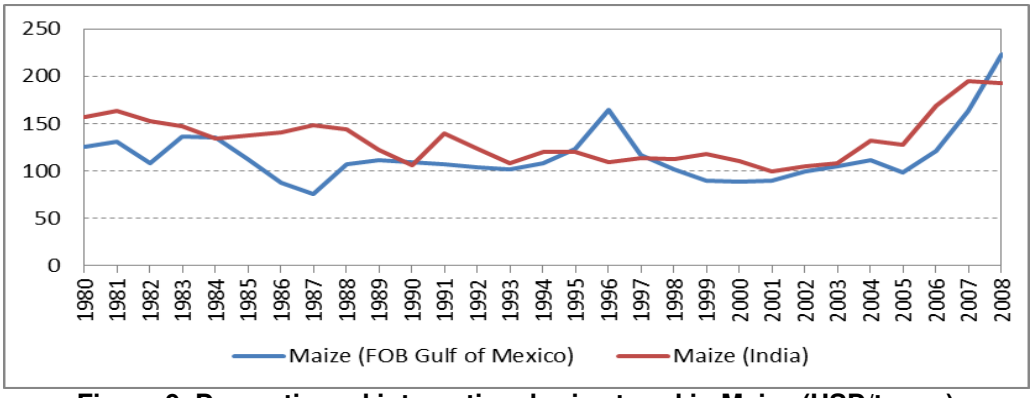


Figure 9. Domestic and international price trend in Maize (USD/tonne)

Prices of rice and wheat, the staple foodgrains of India have not been affected by the increase in international prices which can be attributed to (a) an increasing trend in domestic production (Table 8); (b) timely and high degree of government intervention in the domestic market (Kozicka et al., 2014); and (c) considerable insulation of the cost of production from transmission of the increase in crude oil prices in the international market (Acharya et al., 2012). They also found that the monthly index numbers of international and domestic prices of both rice and wheat has been almost in the opposite direction despite the global food crisis. The wide argument towards changes in international prices creeping into the domestic economy depends on several factors viz., quality of grains, distance and transportation costs, and most importantly the trade policy wedges (Acharya et al., 2012).

Johansen's cointegration method has been applied to test for existence of cointegration between international and domestic prices for the selected commodities. The following section presents the results of unit root test for the levels and first/second differenced price series (Table 7) prior testing for cointegration. The Augmented Dickey-Fuller test statistic indicates that barring rice in post-WTO and overall period, rest of the price series have unit root at their levels. The cointegration test revealed the Eigen value and the trace statistic for each set of price variables (Table 7). For market integration, the estimated Eigen value from the test ought to be close to one and the trace test has been used to ascertain its significance. The test rejects the null hypothesis of no cointegration between the selected pairs (r=0) at 5 per cent level of probability, indicating the presence of one cointegration equation between them. The analysis indicated that with the exception of rice in pre-WTO, the rest of the commodities were not integrated both in the short-run and long-run. In contrast, post-WTO period exhibited the absence of integration between the domestic and international prices despite a significant short-run correlation. Overall, rice markets are not integrated confirming the absence of price integration and log-run equilibrium in corroborating the findings of Acharya et al. (2012) and Baylis et al. (2013). Baylis et al. (2013) also found that domestic and international rice markets were integrated prior to the export ban on April 1, 2008 on account of food crisis indicating that domestic policies in trade have stopped price transmission from international markets into India. Dasgupta et al. (2011) identified weak price integration between wheat markets due to intermediation by policy wedges and other domestic factors. In addition, they found that Public Distribution System (PDS) has played a significant role in stabilizing the Indian prices of rice and wheat. Despite market integration in the post-WTO period, contingent trade policy instruments like ban on export, import duties or restrictions, canalization, and imposition of minimum export prices (MEPs) as enumerated chronologically in Acharya et al., (2012) have stopped price transmission from the international markets to the domestic markets (Dasgupta etal., 2011 and Baylis et al., 2013). If price transmission had occurred, rural poor in India would have been affected to a larger extent (De Janvry and Sadoulet, 2009).

Table 7. Estimated correlation, unit root test statistic and Johansen's cointegration test statistic

Commodity	Correlation coefficient	Unit root test statistic			Johansen's cointegration test statistic			
		Level series	Differenced series	Order	Lag length (SIC Value)	H_0: rank= r	Eigen value	Trace Statistic
Pre-WTO (1980-1994)								
Rice								
A. India	0.63^	-2.56	-4.28**	I(1)	1	r = 0*	0.70	20.95
B. Thailand		-3.60	-3.38*	I(1)	(-1.72)	r ≤1*	0.33	5.15
Wheat								
A. India	0.28	-4.57	-4.49**	I(1)	1	r = 0	0.47	10.46
B. Gulf of Mexico		-2.60	-3.85*	I(1)	(-2.90)	r ≤1	0.16	2.19
Maize								
A. India	0.23	-4.19	-4.80**	I(1)	1	r = 0	0.49	11.90
B. Gulf of Mexico		-2.54	-3.08*	I(1)	(-2.18)	r ≤1	0.21	3.05
Post-WTO (1995-2008)								
Rice								
A. India	0.75^	-1.17	-2.85	I(0)	1	r = 0	0.52	9.29
B. Thailand		0.98	-0.40	I(0)	(-0.49)	r ≤1	0.05	0.59
Wheat								
A. India	0.88^	-0.23	-6.96**	I(2)	1	r = 0*	0.79	19.27
B. Gulf of Mexico		-0.21	-5.05**	I(2)	(-2.47)	r ≤1	0.03	0.36
Maize								
A. India	0.73^	-1.26	-5.96**	I(1)	1	r = 0*	0.75	16.68
B. Gulf of Mexico		-0.12	-7.72**	I(1)	(-1.59)	r ≤1	0.00	0.01
Overall (1980-2008)								
Rice								
A. India	0.70^	-0.03	-0.51	I(0)	1	r = 0	0.33	11.26
B. Thailand		-0.50	-2.59	I(0)	(-0.99)	r ≤1	0.01	0.28
Wheat								
A. India	0.79^	-0.28	-4.40**	I(1)	2	r = 0*	0.29	9.23
B. Gulf of Mexico		-1.93	-3.69**	I(1)	(-2.74)	r ≤1	0.01	0.36
Maize								
A. India	0.59^	-0.73	-5.28	I(1)	1	r = 0*	0.36	12.59
B. Gulf of Mexico		-1.07	-3.93**	I(1)	(-1.74)	r ≤1	0.02	0.62

Note: **and * indicate the significance at one and five per cent level of MacKinnon (1996) one-sided p-values.
^ indicates the significance of Pearson's correlation coefficient at one per cent level of probability (2 tailed).

4. Climate change vis-à-vis price volatility: There is empirical evidence to show that weather plays spoilsport in crop production (Table 8 to 10). The production of all food commodities has shown a decline with the exception of pulses in 2009-10 being a drought year, evidenced by the high WPI for foodgrains (14.49 %). But, most of the food items witnessed a bumper production in 2011-12 with rice and wheat at an all-time high of 105.31 mt and 94.98 mt respectively. The annual change in WPI of these crops was 3.87 per cent and 3.05 per cent. In 2012-13 cropping season, rice and wheat have registered a low production in comparison to their previous record and hence, the inflation rose to 13.41 and 12.69 per cent respectively from their previous lowest points. Correlation analysis indicated a strong negative relation between the current year production and per cent change in annual price index for foodgrains in general and rice and wheat in particular. Preponderantly, the analysis is a reflection of the benefit derived out of procurement and stocking of foodgrains for food security at times of crisis and to contain volatile prices.

Table 8. Role of weather on production risk

Commodities	Unit	Overall weather situation with respect to agriculture								
		Normal	Normal	Normal	Normal	Normal	Drought	Normal	Normal	Normal
		Average production								
		2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
A. Foodgrains (cereals + pulses)	mt	198.36	208.60	217.28	230.78	234.47	218.11	244.49	259.32	255.36
A1. Cereals	mt	185.23	195.22	203.08	216.01	219.90	203.45	226.25	242.23	236.92
Rice	mt	83.13	91.79	93.36	96.69	99.18	89.09	95.98	105.31	104.4
Wheat	mt	68.64	69.35	75.81	78.57	80.68	80.80	86.87	94.88	92.46
Jowar	mt	7.24	7.63	7.15	7.93	7.25	6.70	7.00	6.01	5.33
Bajra	mt	7.93	7.68	8.42	9.97	8.89	6.51	10.37	10.28	8.74
Maize	mt	14.17	14.71	15.10	18.96	19.73	16.72	21.73	21.76	22.23
Barley	mt	1.21	1.22	1.33	1.20	1.69	1.35	1.66	1.62	1.74
Ragi	mt	2.43	2.35	1.44	2.15	2.04	1.89	2.19	1.93	1.59
A2. Pulses	mt	13.13	13.38	14.20	14.76	14.57	14.66	18.24	17.09	18.44
Gram	mt	5.47	5.60	6.33	5.75	7.06	7.48	8.22	7.70	8.88
Arhar	mt	2.35	2.74	2.31	3.08	2.27	2.46	2.86	2.65	3.07
B. Fruits and vegetables										
B1. Vegetables	mt	-	-	-	-	106.37	133.74	146.55	156.33	160.29
Potato	mt	23.63	23.91	28.60	34.66	34.39	36.58	42.34	41.48	42.48
Sweet potato	mt	-	-	-	1.09	1.12	1.09	1.13	1.07	1.09
Onion	mt	6.43	8.68	8.89	13.90	13.56	12.21	15.12	17.51	16.82
Tapioca	mt	7.46	7.92	8.23	9.06	9.62	8.06	8.08	8.75	-
Ginger(fresh)	mt	-	-	-	-	0.61	0.68	0.70	-	-
Peas(green)	mt	-	-	-	2.49	2.92	3.01	3.52	3.74	3.91
Tomato	mt	-	-	-	10.30	11.15	12.43	16.83	18.65	19.38
Cauliflower	mt	-	-	-	5.78	6.53	6.40	6.52	7.35	7.46
Brinjal	mt	-	-	-	9.68	10.38	10.16	10.30	-	-
Okra (lady finger)	mt	3.51	3.67	3.90	4.18	4.53	4.80	5.78	6.26	-
Cabbage	mt	-	-	-	5.91	6.87	7.28	7.95	8.41	8.60
B2. Fruits										
Banana	mt	16.23	18.70	21.00	23.20	26.22	26.47	29.78	28.46	30.28
Apple	mt	1.74	1.81	1.62	2.00	1.99	1.78	2.89	2.20	1.85
Orange	mt	1.24	1.31	1.36	1.46	1.63	2.08	3.26	0.33	0.24
Papaya	mt	2.54	2.32	2.40	2.91	3.63	3.91	4.20	4.46	4.74
Grapes	mt	1.56	1.65	1.69	1.73	1.88	0.88	1.23	2.22	2.69
Guava	mt	1.68	1.82	1.86	1.98	2.27	2.57	2.46	2.51	2.61
Litchi	mt	0.37	0.38	0.40	0.42	0.42	0.50	0.50	0.54	0.55
Lemon	mt	1.49	1.79	2.31	2.50	2.57	2.63	2.11	2.27	2.34
Sapota	mt	1.08	1.12	1.22	0.97	1.01	1.35	1.42	1.43	1.59
C. Milk	mt	-	-	-	107.94	112.18	116.42	121.84	127.90	-
D. Eggs, meat and fish										
Egg	mt	-	-	-	520.67	539.86	587.28	614.20	-	-
Fish-inland	mt	3525.88	375.56	3844.89	4207.35	4637.90	4894.14	5197.83	-	-
Fish-marine	mt	2778.88	281.61	302.42	2919.49	2978.19	3103.85	3224.69	-	-
E. Condiments and spices										
Betelnut/ Arecanut	mt	0.45	0.48	0.47	0.48	0.48	0.48	0.48	0.68	0.70

Note: banded cells indicate the category of weather situation specific to the crop

Drought Season **Heavy Rainfall/ Flood** **Favourable Weather**

Table 9. Annual WPI for different food articles

Commodities	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
A. Foodgrains (cereals + pulses)	100.08	107.26	122.41	130.88	145.30	166.36	174.43	180.72	207.13
A1. Cereals	100.08	105.99	116.74	127.86	143.09	161.18	169.67	176.23	199.87
Rice	100.02	105.23	110.03	122.46	140.62	157.93	167.19	172.29	194.16
Wheat	100.21	105.02	125.12	134.28	147.57	166.47	171.44	168.29	194.39
Jowar	100.03	109.53	124.62	147.99	151.19	168.60	189.54	248.55	235.81
Bajra	100.03	110.48	122.46	128.02	139.15	168.07	175.58	193.21	233.47
Maize	100.05	113.10	122.49	130.23	139.10	153.34	168.94	205.63	234.03
Barley	100.12	114.84	123.71	136.59	152.86	150.60	165.68	180.19	208.03
Ragi	100.00	101.36	112.17	123.36	134.93	174.67	173.79	204.92	278.31
A2. Pulses	99.99	113.34	149.18	144.93	155.84	190.76	196.86	201.82	241.32
Gram	99.98	113.94	156.15	148.98	153.79	152.16	149.97	193.78	266.31
Arhar	99.90	98.05	108.31	126.08	144.28	214.70	205.06	183.20	199.35
Moong	100.04	121.66	160.30	141.18	150.42	233.80	280.44	244.42	259.47
Masur	100.02	102.51	114.97	145.68	196.16	228.16	194.45	162.78	193.87
Urad	100.03	131.08	191.33	159.77	159.78	228.43	271.75	240.00	227.67
B. Fruits and vegetables	99.88	108.00	111.78	124.63	134.86	147.76	172.05	183.15	198.40
B1. Vegetables	99.79	113.71	114.28	137.07	141.89	161.80	182.83	179.26	210.08
Potato	99.74	118.51	132.59	146.85	110.29	206.24	131.95	128.98	206.95
Sweet potato	99.97	114.66	146.48	145.81	148.81	184.70	194.14	205.97	198.24
Onion	100.00	126.62	115.90	174.68	177.75	204.30	259.60	186.67	232.51
Tapioca	99.82	95.55	112.78	134.71	159.60	240.78	282.82	285.63	286.89
Ginger(fresh)	99.32	70.39	44.18	57.72	98.22	106.65	114.54	79.98	83.21
Peas(green)	98.87	108.48	99.43	125.72	128.28	127.67	144.87	174.70	182.47
Tomato	100.31	119.05	125.56	123.82	153.24	153.56	190.39	184.39	172.30
Cauliflower	99.38	101.32	97.45	101.45	125.52	124.38	169.87	145.93	153.00
Brinjal	99.96	114.31	116.43	130.53	142.75	139.13	164.66	170.97	186.18
Okra (lady finger)	100.29	102.68	115.24	123.33	133.84	145.53	174.80	237.15	232.56
Cabbage	100.45	127.32	119.51	157.11	168.51	150.65	214.58	211.59	271.96
B2. Fruits	99.98	103.27	109.68	114.38	129.08	136.17	163.17	186.37	188.79
Banana	100.08	110.57	115.28	120.56	132.45	146.62	163.01	173.42	210.53
Mango	100.10	95.03	101.93	110.40	151.65	141.97	191.52	237.15	219.68
Apple	99.94	100.88	124.79	124.62	134.74	171.23	173.59	220.38	241.42
Orange	100.18	113.30	123.23	113.49	138.25	148.63	185.32	237.35	228.29
Cashew nut	100.07	106.67	110.64	106.12	117.04	136.57	151.04	192.09	190.55
Coconut (fresh)	100.09	85.03	82.19	83.05	95.88	85.58	97.77	118.20	115.44
Papaya	99.99	92.08	94.97	110.14	137.11	154.80	189.62	186.97	139.67
Grapes	99.92	98.72	109.85	126.48	127.17	124.78	188.85	221.20	195.87
Pineapple	99.83	94.25	97.89	116.28	128.82	154.43	177.92	193.45	233.43
Guava	100.02	119.92	121.32	120.38	125.20	110.43	177.67	148.32	99.83
Litchi	100.00	9999.90	9999.90	79.70	77.10	102.70	179.20	119.70	153.00
Lemon	99.77	131.73	165.05	194.99	183.42	164.70	197.49	236.16	216.85
Sapota	100.05	101.28	100.43	124.07	116.20	149.04	174.02	209.45	232.81
C. Milk	100.00	101.01	108.98	114.58	123.24	146.41	175.88	194.01	208.05
D. Eggs, meat and fish	99.94	106.29	112.77	116.37	125.38	151.48	190.13	214.33	244.52
Egg	100.06	102.12	104.83	119.89	126.47	143.58	165.44	181.79	195.99
Fish-inland	100.02	118.14	108.52	101.38	101.37	152.63	193.43	250.82	303.68
Fish-marine	99.84	103.20	120.97	125.65	146.23	160.53	222.84	246.72	278.75
Mutton	99.93	105.05	117.81	124.79	139.50	175.06	187.17	200.10	220.26
Beef & buffalo meat	100.02	111.66	116.55	119.69	121.20	142.99	188.20	199.62	202.02
Poultry chicken	99.95	96.39	101.19	105.78	106.40	117.70	141.16	136.56	156.89
Pork	99.99	108.62	122.91	154.15	156.62	167.45	197.50	219.93	240.06
E. Condiments and spices	99.95	94.54	136.71	142.93	151.24	182.68	243.98	237.53	209.50
Black pepper	99.82	92.71	132.45	184.63	180.80	186.27	247.12	402.93	518.98
Chillies (dry)	99.96	83.92	162.35	157.08	182.61	205.20	221.80	277.12	235.13
Turmeric	99.95	90.45	88.14	82.77	105.42	210.32	401.72	214.87	166.32
Cardamom	99.79	84.65	93.49	124.40	141.33	206.56	348.22	291.35	277.24
Ginger (dry)	100.15	100.02	81.89	82.57	98.60	103.10	119.25	90.11	91.31
Betelnut/ Arecanut	100.03	107.91	139.47	141.09	139.29	141.61	154.69	209.79	226.68
Cummin	99.95	100.13	107.36	125.76	124.42	150.33	163.35	188.49	193.04
Garlic	99.76	92.77	202.27	211.47	132.02	228.07	410.12	281.12	110.87
Corriander	99.83	110.63	140.64	185.46	321.91	212.26	174.06	216.17	220.70
F. Other food articles	100.04	107.77	126.62	132.78	175.03	196.17	181.94	216.45	242.19
Tea	100.10	88.88	104.21	104.40	153.21	174.06	148.33	150.85	198.56
Coffee	100.01	137.63	162.04	177.61	209.48	231.07	235.01	320.08	311.09

Table 10. Per cent change in WPI and correlation between production and price index change

Commodities	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Correlation*
A. Foodgrains (cereals + pulses)	7.17	14.12	6.92	11.02	14.49	4.85	3.61	14.61	-0.30
A1. Cereals	5.91	10.14	9.53	11.91	12.64	5.27	3.87	13.41	-0.16
Rice	5.21	4.56	11.30	14.83	12.31	5.86	3.05	12.69	0.02
Wheat	4.80	19.14	7.32	9.90	12.81	2.99	-1.84	15.51	-0.27
Jowar	9.50	13.78	18.75	2.16	11.52	12.42	31.13	-5.13	0.19
Bajra	10.45	10.84	4.54	8.69	20.78	4.47	10.04	20.84	-0.70
Maize	13.04	8.30	6.32	6.81	10.24	10.17	21.72	13.81	0.35
Barley	14.70	7.72	10.41	11.91	-1.48	10.01	8.76	15.45	0.26
Ragi	1.36	10.66	9.98	9.38	29.45	-0.50	17.91	35.81	-0.61
A2. Pulses	13.35	31.62	-2.85	7.53	22.41	3.20	2.52	19.57	-0.24
Gram	13.96	37.05	-4.59	3.23	-1.06	-1.44	29.21	37.43	0.24
Arhar	-1.85	10.46	16.41	14.44	48.81	-4.49	-10.66	8.82	-0.27
Moong	21.61	31.76	-11.93	6.54	55.43	19.95	-12.84	6.16	-
Masur	2.49	12.15	26.71	34.65	16.31	-14.77	-16.29	19.10	-
Urad	31.04	45.96	-16.50	0.01	42.97	18.96	-11.68	-5.14	-
B. Fruits and vegetables	8.13	3.50	11.50	8.21	9.57	16.44	6.45	8.33	-
B1. Vegetables	13.95	0.50	19.94	3.52	14.03	13.00	-1.95	17.19	0.24
Potato	18.82	11.88	10.75	-24.90	87.00	-36.02	-2.25	60.45	-0.02
Sweet potato	14.69	27.75	-0.46	2.06	24.12	5.11	6.09	-3.75	-0.12
Onion	26.62	-8.47	50.72	1.76	14.94	27.07	-28.09	24.56	-0.10
Tapioca	-4.28	18.03	19.44	18.48	50.86	17.46	0.99	0.44	-0.06
Ginger(fresh)	-29.13	-37.24	30.65	70.17	8.58	7.40	-30.17	4.04	-0.98
Peas(green)	9.72	-8.34	26.44	2.04	-0.48	13.47	20.59	4.45	-0.17
Tomato	18.68	5.47	-1.39	23.76	0.21	23.98	-3.15	-6.56	-0.27
Cauliflower	1.95	-3.82	4.10	23.73	-0.91	36.57	-14.09	4.84	-0.32
Brinjal	14.36	1.85	12.11	9.36	-2.54	18.35	3.83	8.90	-0.01
Okra (lady finger)	2.38	12.23	7.02	8.52	8.73	20.11	35.67	-1.94	0.89
Cabbage	26.75	-6.13	31.46	7.26	-10.60	42.44	-1.39	28.53	-0.03
B2. Fruits	3.29	6.21	4.29	12.85	5.49	19.83	14.22	1.30	-
Banana	10.48	4.26	4.58	9.86	10.70	11.18	6.39	21.40	0.53
Mango	-5.06	7.26	8.31	37.36	-6.38	34.90	23.83	-7.37	-
Apple	0.94	23.70	-0.14	8.12	27.08	1.38	26.95	9.55	-0.36
Orange	13.10	8.76	-7.90	21.82	7.51	24.69	28.08	-3.82	0.26
Cashew nut	6.60	3.72	-4.09	10.29	16.69	10.60	27.18	-0.80	-
Coconut (fresh)	-15.05	-3.34	1.05	15.45	-10.74	14.24	20.90	-2.34	-
Papaya	-7.91	3.14	15.97	24.49	12.90	22.49	-1.40	-25.30	-0.14
Grapes	-1.20	11.27	15.14	0.55	-1.88	51.35	17.13	-11.45	-0.38
Pineapple	-5.59	3.86	18.79	10.78	19.88	15.21	8.73	20.67	-
Guava	19.90	1.17	-0.77	4.00	-11.80	60.89	-16.52	-32.69	-0.25
Litchi	9899.90	0.00	-99.20	-3.26	33.20	74.49	-33.20	27.82	-0.51
Lemon	32.03	25.29	18.14	-5.93	-10.21	19.91	19.58	-8.18	-0.74
Sapota	1.23	-0.84	23.54	-6.34	28.26	16.76	20.36	11.15	0.34
C. Milk	1.01	7.89	5.14	7.56	18.80	20.13	10.31	7.24	0.47
D. Eggs, meat and fish	6.35	6.10	3.19	7.74	20.82	25.51	12.73	14.09	-
Egg	2.06	2.65	14.37	5.49	13.53	15.22	9.88	7.81	0.43
Fish-inland	18.12	-8.14	-6.58	-0.01	50.57	26.73	29.67	21.07	0.11
Fish-marine	3.37	17.22	3.87	16.38	9.78	38.82	10.72	12.98	0.33
Mutton	5.12	12.15	5.92	11.79	25.49	6.92	6.91	10.07	-
Beef & buffalo meat	11.64	4.38	2.69	1.26	17.98	31.62	6.07	1.20	-
Poultry chicken	-3.56	4.98	4.54	0.59	10.62	19.93	-3.26	14.89	-
Pork	8.63	13.16	25.42	1.60	6.91	17.95	11.36	9.15	-
E. Condiments and spices	-5.41	44.61	4.55	5.81	20.79	33.56	-2.64	-11.80	-
Black pepper	-7.12	42.86	39.40	-2.07	3.03	32.67	63.05	28.80	-
Chillies (dry)	-16.05	93.46	-3.25	16.25	12.37	8.09	24.94	-15.15	-
Turmeric	-9.50	-2.55	-6.09	27.36	99.51	91.00	-46.51	-22.60	-
Cardamom	-15.17	10.44	33.06	13.61	46.15	68.58	-16.33	-4.84	-
Ginger (dry)	-0.13	-18.13	0.83	19.41	4.56	15.66	-24.44	1.33	-
Betelnut/ Arecanut	7.88	29.25	1.16	-1.28	1.67	9.24	35.62	8.05	0.42
Cummin	0.18	7.22	17.14	-1.07	20.82	8.66	15.39	2.41	-
Garlic	-7.01	118.03	4.55	-37.57	72.75	79.82	-31.45	-60.56	-
Corriander	10.82	27.13	31.87	73.57	-34.06	-18.00	24.19	2.10	-
F. Other food articles	7.73	17.49	4.86	31.82	12.08	-7.25	18.97	11.89	-
Tea	-11.21	17.25	0.18	46.75	13.61	-14.78	1.70	31.63	-
Coffee	37.62	17.74	9.61	17.94	10.31	1.71	36.20	-2.81	-

Note: * indicates the Pearson's correlation coefficient for the available data.

5. Population pressure on price volatility: There is a considerable evidence of price volatility due to burgeoning population on literature, and the present study has supported the findings in terms of changes in the share of labour force. In 2009, as the labour force drastically reduced from 523.50 million to 467 million (-10.79 %), the inflation in foodgrains registered its peak (Table 11) owing to the reduction in supply coupled with drought in that period. Due to the rise in food prices, which undermine the purchasing power, particularly the poor people, the share of below poverty line (BPL) has increased from 25 per cent in 2007 to 29.8 per cent in 2010 (Source: CIA World Factbook). In actual numbers, it is estimated at 13.43 million.

Table 11. Relation between price volatility, inflation and labour force

Year	Population (billion)	Labour force (million)	Cuddy-Della Valle index (%)				Inflation (%)			
			Food articles	Foodgrains	Rice	Wheat	Food articles	Foodgrains	Rice	Wheat
2005	1.08	496.40	2.30	1.85	0.45	7.21	-	-	-	-
2006	1.10	509.30	1.88	0.76	0.92	3.53	8.63	13.84	3.22	20.25
2007	1.13	516.40	1.40	2.72	0.59	4.61	9.27	8.82	10.10	9.55
2008	1.15	523.50	2.42	0.88	1.09	1.19	7.26	9.25	14.24	8.75
2009	1.17	467.00	2.68	0.51	1.96	1.29	12.73	13.59	13.74	10.58
2010	1.17	478.30	1.54	2.84	1.75	4.76	17.70	8.62	7.56	7.78
2011	1.19	487.60	2.31	0.56	1.19	1.91	9.09	2.72	3.24	-1.58

6. Consumption, stocks and trade (rice and wheat) vis-à-vis price volatility: The observations for elucidating demand (consumption is taken as a proxy variable) and level of stocks as drivers of volatility follows invariably the law of demand (Table 12). Consumption has dropped in a year with high volatility in the preceding year. Also, at a higher point of inflation, the subsequent year total supply has been increased with more addition of stocks. In the case of rice, exports has nothing much to do with the price volatility as the volatility is already at low level. However a year with high inflation follows a year with more procurement in the case of rice (Table 12) but not in wheat (Table 13).

Table 12. Level of consumption, stocks and trade on volatility in rice price

Year	Domestic Consumption ('000 t)	Exports ('000 t)	Ending Stocks ('000 t)	Total Supply ('000 t)	Beginning Stocks ('000 t)	Procurement ('000 t)	Cuddy-Della Valle index (%)	Inflation (%)
2006	86700	5740	11430	103870	10520	27578	0.92	-
2007	90466	4654	13000	108120	11430	25107	0.59	4.56
2008	91090	2090	19000	112180	13000	28736	1.09	11.30
2009	85508	2082	20500	108090	19000	34102	1.96	14.83
2010	90206	2774	23500	116480	20500	32034	1.75	12.31
2011	93334	10376	25100	128810	23500	34198	1.19	5.86
2012	93500	11000	25000	129500	25100	35060	1.22	3.05
2013	96000	10000	24000	130000	25000	32435	1.51	12.69

Data source: Compiled from Food Corporation of India (FCI), indexmundi and Office of the Economic Adviser, India.

Table 13. Level of consumption, stocks and trade on volatility in wheat price

Year	Domestic Consumption ('000 t)	Exports ('000 t)	Imports ('000 t)	Ending Stocks ('000 t)	Total Supply ('000 t)	Beginning Stocks ('000 t)	Net exports ('000 t)	Procurement ('000 t)	Cuddy-Della Valle index (%)	Inflation (%)
2006	73477	94	6721	4500	78071	2000	-6627	147.85	3.53	-
2007	76423	49	1962	5800	82272	4500	-1913	92.31	4.61	19.14
2008	70924	23	7	13430	84377	5800	16	111.28	1.19	7.32
2009	78150	58	218	16120	94328	13430	-160	226.89	1.29	9.90
2010	81760	72	272	15360	97192	16120	-200	253.82	4.76	12.81
2011	81404	891	15	19950	102245	15360	876	225.25	1.91	2.99
2012	83822	6824	16	24200	114846	19950	6808	283.35	2.21	-1.84
2013	89970	6500	10	20200	116670	24200	6490	38148	2.60	15.51

Data source: Compiled from Food Corporation of India (FCI), indexmundi and Office of the Economic Adviser, India.

Impact on individual and society

Food price volatility vis-à-vis economic growth remains a controversial topic in both theoretical and empirical economics. With its origin in 1950s in the Latin American context, an enduring debate does exist between 'structural' and 'monetary' economists. Despite structuralists belief that rising prices are essential for economic growth, monetarists view it as detrimental to economic progress. Friedman (1973) has summarized the inconclusive nature of the relationship with all possible combinations *viz.,* inflation with and without development, no inflation with and without development. Underlying the price volatility is the ultimate concern for food security of the poor economies though the net producers may even benefit out of inflation (Wodon et al., 2008). Foodgrains accounts for about four-fifth of the calorie intake and a very high share of the total budget of the poorest households. High prices would undermine the purchasing power, resulting in inadequate access to food and calorie consumption and thereby push millions into poverty (Nasurudeen et al., 2006). Both income effect and substitution effect on food consumption by poor is high following a price rise and it has a serious implication on the household welfare. Bellemare et al. (2013) empirically proved that price stabilisation has resulted in net welfare gains but in a distributional regressive pattern for the rural households in Ethiopia.

Dasgupta et al. (2012) postulated that a 10 per cent change in wheat price would change the overall food inflation near to one per cent ignoring any cross-price effects on other foods. If the cross-price effects are to be included, then the change would be around two per cent. The gravity of inflation manifests in substitutions, reductions and deprivations among the poor in India – it may be a shift from fine varieties of grains to coarse varieties to coarse cereals as staples, ghee to refined oil to ordinary oil as cooking medium, red meat to white to fish to egg to vegetarian diet, two vegetables in daily diet to one, packaged/tinned juices to processed to raw fruits, sugar to gur, coffee to tea, eat outs to parcels to home cooked food, personal to public transport to physical commuting, to cite a few. This can be captured through analysis of consumption expenditure surveys conducted periodically.

Price volatility distorts the optimal production decisions as the down side lowers the income and the upside poses a threat of enhanced expected losses (World Bank, 1997; Martins et al, 2010). Many households in developing economies are both producers and consumers of agro-products and volatile prices create them complex problems (Rapsomanikis, 2009). Certain price variation is required to reflect market fundamentals, but it becomes an issue evoking policy response when it affects the interests of producers and consumers and capacity of nations to cope. What constitutes excessive volatility depends very much on the situation of the individual or nation. Poor consumers in less developed countries without access to adequate social security or safetynet are the most immediately affected by price surges. Small, resource limited farmers face particularly severe problems when prices fall. The volatility during the 2007-2008, affected poor countries importing food forcing severe economic, social and political stress. However, Bellemare (2014) proved that increase in the overall prices of fooditems led to the increase in social unrest, but, the price volatility has no association with the increase in the social unrest.

Existing price stabilization measures

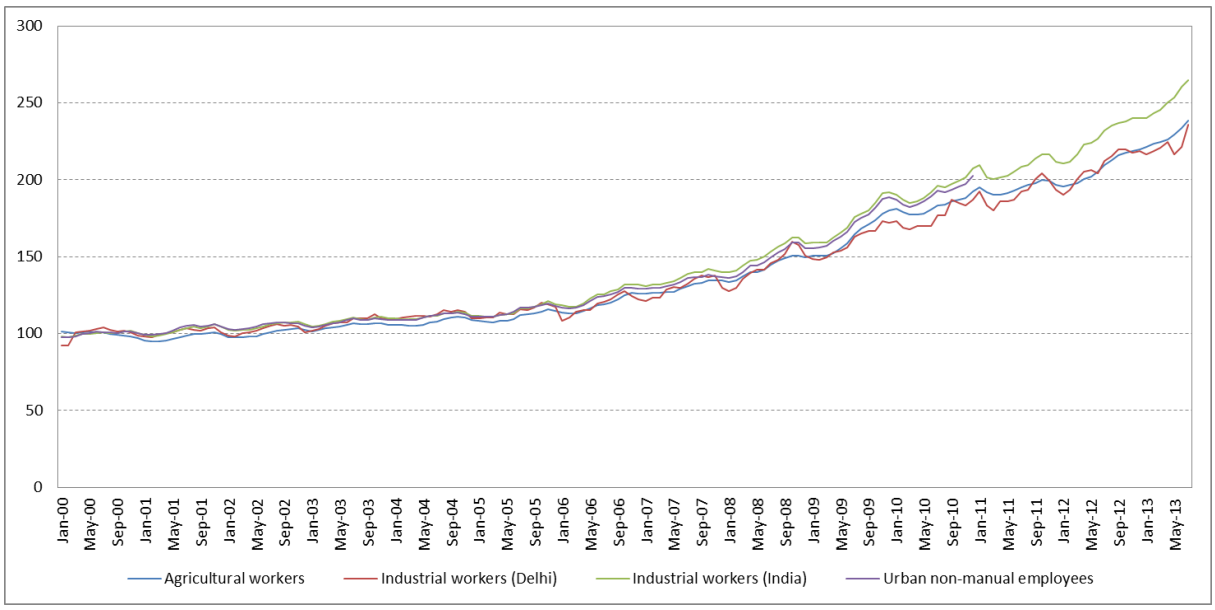
This section enumerates the general measures taken by the government to stabilize prices at times of food inflation. However, economists sometime quote the traditional policy instruments as blunt (Dasgupta et al., 2011). The usual policy instruments to build sufficient food stocks and stabilize domestic food prices are listed as follows:

- Announcement of minimum support price (MSP) before sowing which helps to decide the acreage well in advance which encourage the producers for targeted food production.
- Procurement of major food commodities including rice and wheat at the minimum support price and stocking for food security.
- Maintenance of buffer stocks by the government for rice and wheat including the strategic reserve at the Food Corporation of India.
- Distribution to consumers and highly subsidised rationing to vulnerable section through fair price shops.
- Exim policies for favourable terms of trade.
- Trade policy instruments like export bans, import duties or restrictions, canalization, and imposition of minimum export prices (MEPs).
- Contingent adjustments in national agricultural policy.
- Regional supply arrangements like in the case of onion crisis (2010 and 2013) by the government.
- Futures trading in selected agricultural commodities and delisting a few under limited supplies.

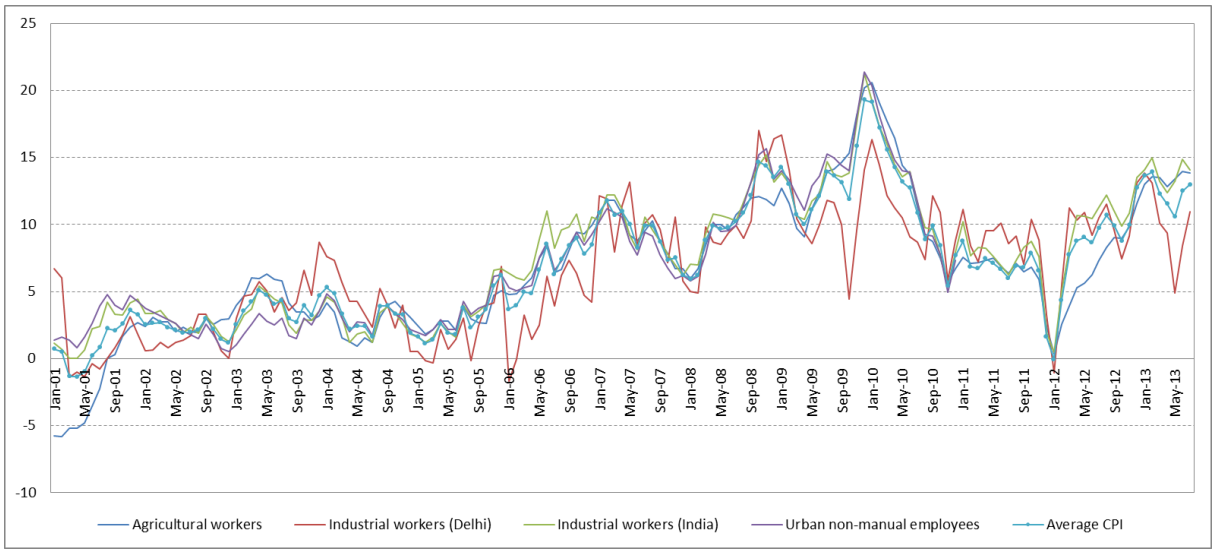
Challenges ahead and policy implications

As agriculture is exposed to vagaries of monsoon and global trade, India needs to have an effective food management strategy against volatile prices which will aggravate the existing food and nutrient deficiency. It also needs to explore various other options for price stabilisation apart from maintaining buffer stocks, strategic reserves and utilizing the benefit out of international trade. There is a need to enhance the efficiency in supply chain management in order to save the wastages in food commodities. Food markets have to be regulated and encouraged for public-private partnership in grain management. All developing economies and food deficit countries should invest heavily in establishing a strong institutional mechanism for an early warning system relating to food demand, supply and price situation for better terms of trade during food crisis. Variation in agricultural output forces to import a commodity at higher costs than what has been exported during years of surplus production. India being a net exporter of food in general, and rice and wheat in particular, a substantial part has to be stocked for food security. Hence, additional investments should be made to increase the storage capacity for various types of foods in both the public as well as private sectors. With futures being blamed for food inflation, an exclusive market regulator for agricultural commodities should be established to monitor and control the speculative trading. To maintain volatility at a low level, a strong and committed action has to be initiated for surplus food production by developing and disseminating the improved production technologies. Taking these focused and pragmatic policy instruments in a synchronized manner will not only help in managing the food price volatility but also result in higher agriculture growth coupled with reduction in poverty.

Appendix – 1: Trends and annual change in the Consumer Price Index (CPI)



Trends in the CPI



Annual change in the CPI

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