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Price Transmission and Volatility Spillover in Food Grain Market: Experience from Indian vis-à-vis World Market

SUBHRA SINHA*
ARINDAM LAHA**

In the backdrop of liberalised trade of agricultural commodities in the twenty-first century, world food prices have risen at a faster pace since 2007. The Indian economy has largely been able to insulate itself from the price transmission mechanism of the world market because of low exposure of the economy to global factors. This paper analyses the trend of volatility in the price of rice and wheat in the world market vis-à-vis regional markets in India during 2000-15. In addition, an econometric analysis was conducted to measure the price transmission mechanism in understanding the process of volatility spillover from international to domestic markets.

Keywords: Price Transmission, Volatility Spillover, Food Grain, Pass-through Effect, International Price, Domestic Price

JEL Classification: Q11, Q17

I. INTRODUCTION

In developing world, agriculture is seen to be exposed to many risks, e.g. like production, market participation, institutional capacity, and financial risks. However, the presence of uncertainty in the prices of the harvested produce, as measured by the market risk, is observed to be the most important risk faced by farmers (OECD 2009). The risk is magnified through the international transmission of world price volatility. In the world commodity market, agricultural commodity volatility was low in the 1960s, higher in the 1970s and again fell back in the second half of the 1980s and the 1990s (Gilbert 2006). In the backdrop of liberalised trade of agricultural commodities in the twenty-first century, world food prices rose at a faster pace since 2007. Spillover of international price volatility in the domestic front is visible in the wake of a

*PhD Research Scholar, Department of Economics, The University of Burdwan, West Bengal, India. E-mail: subhra_sinha2010@yahoo.co.in.
**Assistant Professor, Department of Commerce, The University of Burdwan, West Bengal, India. E-mail:arindamlaha2004@yahoo.co.in.

consistent upward movement of the rate of inflation during the first quarter of the calendar year 2007 (Government of India 2012). However, volatility in domestic prices has been less than in international prices. To explain the evolution of price changes over time, a number of factors were identified in several studies (Gilbert 2010, Gilbert and Morgan 2010). Although there is a consensus regarding the role of market fundamentals (i.e., changes in supply or demand forces), the role of speculation in futures and options trading remained controversial (Gilbert and Morgan 2010, De Schutter 2010, Irwin and Sanders 2010). In this context, an attempt has been made in this paper to analyse the trend of volatility in the prices of two important cereal commodities (viz. rice and wheat) in the world market vis-à-vis Indian market. In addition, this paper explores the mechanism of transmission of prices in understanding the process of volatility spillover from international to domestic market.

II. DATA SOURCES OF THE STUDY

The study is exclusively based on the secondary sources of data. We have used FAO database on Food Price Monitoring and Analysis Tool for collecting international and domestic data on cereal prices. Two important cereal food grains, viz. rice and wheat are chosen for our analysis. In the FAO database, we have used price data on retail and wholesale domestic markets for rice and wheat located at New Delhi, Mumbai, Chennai and Patna. The list of international and domestic prices of rice and wheat is presented in Tables I and II.

TABLE I
LIST OF INTERNATIONAL PRICES OF RICE AND WHEAT IN FAO DATABASE

Origin	Commodity	Currency	Measure
Thailand (Bangkok)	Rice (25% broken)	US Dollar	tonne
India	Rice (25% broken)	US Dollar	tonne
US (Gulf)	Wheat (US No. 2, Hard Red Winter)	US Dollar	tonne
US (Gulf)	Wheat (US No. 2, Soft Red Winter)	US Dollar	tonne

TABLE II
LIST OF DOMESTIC PRICES OF RICE AND WHEAT IN FAO DATABASE

Country	Market	Commodity	Price	Currency	Measure
India	New Delhi	Rice	Retail	Indian Rupee	Kg
India	New Delhi	Rice	Wholesale	Indian Rupee	100 kg
India	Mumbai	Rice	Retail	Indian Rupee	Kg
India	Mumbai	Rice	Wholesale	Indian Rupee	100 kg
India	Chennai	Rice	Retail	Indian Rupee	Kg
India	Chennai	Rice	Wholesale	Indian Rupee	100 kg
India	Patna	Rice	Retail	Indian Rupee	Kg
India	Patna	Rice	Wholesale	Indian Rupee	100 kg
India	New Delhi	Wheat	Retail	Indian Rupee	Kg
India	New Delhi	Wheat	Wholesale	Indian Rupee	100 kg
India	Mumbai	Wheat	Retail	Indian Rupee	Kg
India	Mumbai	Wheat	Wholesale	Indian Rupee	100 kg
India	Chennai	Wheat	Retail	Indian Rupee	Kg
India	Chennai	Wheat	Wholesale	Indian Rupee	100 kg
India	Patna	Wheat	Retail	Indian Rupee	Kg
India	Patna	Wheat	Wholesale	Indian Rupee	100 kg

III. METHODOLOGY

3.1 Measurement of Volatility

Volatility means variability of price series around its central value. In the existing literature, we have come across two types of volatility measures: historical (or realised) volatility and implicit (or expected volatility). Historical volatility is calculated on the basis of past price data. It reveals how volatile a price was in the past. The implicit volatility reveals how volatile a price will be in future. In the present study, we intend to evaluate historical volatility by using coefficient of variation (CV) of the level of prices and standard deviation of the first difference (SDD) in the logarithmic value of prices, i.e.

$$CV = \frac{SD}{Mean} = \frac{\sqrt{\sum_{i=1}^{n}(p_i - \bar{p})^2 \Big/ n}}{\bar{p}}$$

$$SDD = \sqrt{Variance} \times \left(\ln \frac{p_t}{p_{t-1}} \right)$$

It is to be noted that Generalised Auto Regressive Conditional Hetero-scedasticity (GARCH) model is popularly used in financial econometrics for modeling volatility in financial markets. In the model of volatility clustering, we estimate the conditional variance of innovation from the auto-regressive process in a time series data. However, it has been seen that parameters used in this volatility clustering model are not well determined; rather they are poorly determined (Gilbert and Morgan 2010). In the study, we have employed Heteroscedasticity test in order to test the presence of volatility clustering in agricultural commodity prices. However, the existence of ARCH effect is not found significant and thereby provides no justification in employing GARCH model in modeling volatility.

Tests of Equality of Means in Volatility

We have employed tests of equality of means in volatility to determine whether the mean volatility of prices in international market is statistically different from domestic market. Again, this test procedure also considers the difference in volatility of price in one particular market in two different periods of time (pre- and post-2008). In the formulation of hypothesis, the null hypothesis is given by H_0: $MV_1=MV_2$, where MV_1 and MV_2 are the means of the volatility measurement for period 1 and 2 respectively. The t-test statistic can be written as:

$$t = \frac{MV_1 - MV_2}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \approx t_{n_1+n_2-2}$$

where S_1 and S_2 are the standard deviation of the respective periods. Comparing the calculated and tabulated values of the t statistic necessary conclusions can be drawn.

Tests of Equality of Variance in Volatility

We employ variance equality tests to make comparison on the evolution of volatility in the pre- and post-crisis scenario. Again, the test is utilised to compare the variances of international and domestic price differences separately for two time periods. The idea is to compare variances in price differences in the last few years, 2008-15, relative to the pre-crisis time period, 2000-07. In the standard F test, we formulate the null hypothesis $H_0 : \sigma_1^2 = \sigma_2^2$ against the

alternative hypothesis $H_1 : \sigma_1^2 \geq \sigma_2^2$. In the test procedure, the F test statistic can be written as the ratio of two variances for price difference $\left(\frac{s_1^2}{s_2^2}\right) \approx F_{n_1-1, n_2-1}$

3.2 Measurement of Price Transmission Effect

Price transmission mechanism considers the effect of prices in one market on prices in another market. Intuitively, we examine the transmission of international prices to domestic prices as transmission from domestic to international prices is implausible. Measurement of price transmission is estimated by the transmission elasticity, or popularly known as pass through effect. It is generally defined as the percentage change in the price in one market due to one percentage change in the price in another market (Minot 2011). In this paper, we examine how the change in international price (i.e. Thailand and India rice prices; US hard red winter and US soft red winter wheat prices) is transmitted to domestic price (i.e. retail and wholesale rice and wheat prices in New Delhi, Mumbai, Chennai and Patna).

Econometric Analysis of Price Transmission Mechanism

In this study, Vector Error Correction Model (VECM) is employed to examine the relationship between world cereal prices and domestic prices in Indian retail and wholesale markets. For each pair of domestic and world prices, the analysis consists of the following three steps:

Step I: Testing stationarity in price series

The earlier research on price transmission mechanism examined co-movement of prices in different markets by using static regression approaches. However, the basic foundation of regression analysis has been challenged for assuming instantaneous response of price in one market to the change in the price of other markets. As an alternative, Vector Auto Regression (VAR) analysis takes into account the dynamic effects of lagged world price changes on the current domestic price change. The problem of nonstationarity has been recognised in the VAR framework. Static regression analysis assumes that the mean and variance of the price series are constant over time. However, most of the price data are found to be non-stationary with no tendency to revert back to an underlying trend value (i.e. steady state path) as they typically exhibit 'random walk' properties, i.e., today's prices cannot be used to predict future prices (Lokare 2007). This property is best captured by a financial theory known as Random Walk Hypothesis. In this context, one of the most desirable

characteristics of time series data is the property of stationary. A series is said to be stationary if the mean and covariance are constant over time and the auto-covariance of the series depends only on the lag between two time periods-not the actual time at which the covariance is computed. To test the stationary property of the commodity prices, a well known method called Augmented Dickey-Fuller Test (ADF Test) is used. ADF test is an augmented version of the Dickey-Fuller test to accommodate some forms of serial correlation. The ADF test is applied to the following model: $\Delta p_t = \alpha_0 + \gamma p_{t-1} + \sum_{i=1}^{n} \beta_i \Delta p_{t-i} + \varepsilon_t$ where Δp_t= change in the value of p (i.e., $p_t - p_{t-1}$) and ε_t= white noise error term. In the model formulation, the unit root test is carried out under the null hypothesis that γ =1 against the alternative hypothesis of γ <1. In the test procedure, at first, we compute the value of test statistic $\tau = (\hat{\gamma} - 1)/SE(\hat{\gamma})$. once it is computed, it can be compared with the MacKinnon critical values. If the test statistic is more than the critical value then the null hypothesis of γ =1 is rejected and no unit root is present and the series become stationary.

Step II: Testing long run relationship

Co-integration test is performed to know whether there exists a long-term relationship between the domestic and international prices. The co-movement between the prices is examined in the framework of co-integration to identify the linear combination of non-stationary variables. The existence of such co-integrating relationship actually reflects presence of an improved price transmission mechanism in domestic and international markets. In the presence of such transmission mechanism, the price shock in international commodity market would be reflected in domestic markets also. This study employs VAR based co-integration test using the methodology developed by Johansen (1988, 1995). Johansen's method is used to test the restrictions imposed by co-integration on the unrestricted VAR involving the series. The estimation procedure used in Johansen test is based on the error-correction representation of the VAR model with Gaussian errors.

Step III: Testing the effect of world prices on domestic prices in the short run

If there is a long run relationship between domestic and international prices (as represented by co-integrating equation), then it can be said that there would be an error correction representation that indicates the short run responsiveness of all the underlying factors (Engle and Granger 1987). In the Vector Error

Correction (VEC) specification, error correction term is incorporated to show how the deviation from long run equilibrium is corrected gradually through a series of partial short-run adjustments. In such specification, the error correction term provides an estimate of the speed of adjustment. The empirical specification of the error correction mechanism at one lag period can be written as $\Delta P^d{}_t = \alpha + \phi\,(P^d_{t-1} - \beta P^w_{t-1}) + \delta \Delta P^w_{t-1} + \rho \Delta P^d_{t-1} + \varepsilon_t$ where $P^d{}_t$ and $P^w{}_t$ are the co-integrating variables, β = co-integration factor, ϕ = coefficient of the lagged error term representing error correction mechanism, δ = lagged change in world prices and ρ = autoregressive lagged change in domestic prices. However, the study examines in only one portion of VECM, i.e., the transmission of international price shock to domestic prices. Causality from domestic to international prices is not viable proposition in practice. Therefore, the study restricted the analysis on unidirectional basis. Testing of bidirectional causality in the framework of Granger causality test is not plausible in this vector error correction model of our study.

IV. RESULTS AND DISCUSSION

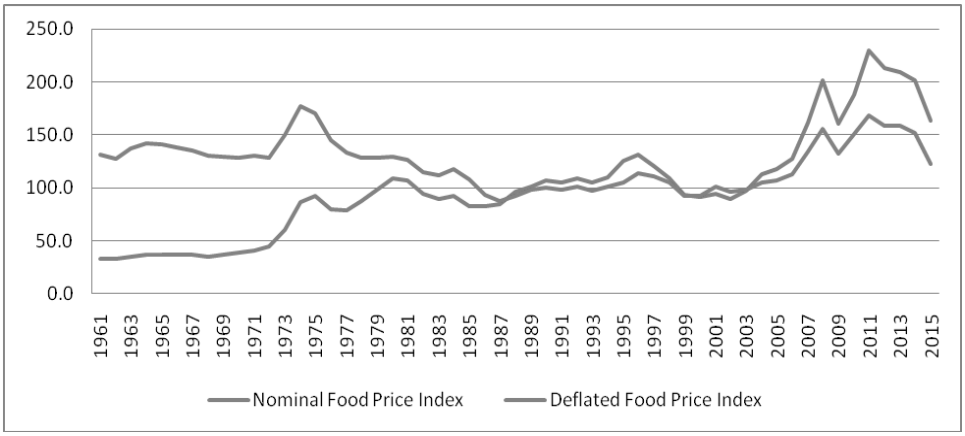
4.1 Trend of Price Movement

Food Price Movement from a Global Perspective

The FAO Food Price Index is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices, weighted with the average export shares of each of the groups for 2002-2004. Similarly, cereal price index is compiled by the FAO by using the International Grains Council wheat price index, itself an average of 10 different wheat price quotations, 1 maize export quotation and 16 rice quotations. Figure 1represents the nominal and deflated food price index for the time period 1961-2015. The time period of analysis can be broadly segregated in three distinct categories: the first period in the sixties can be characterised by a more or less stable food price trend; a sudden acceleration of price in the 1973 and thereafter smoothing of price over the two decades; and departure from their long term stable movement of prices and become increasingly volatile since 2003. Prices increased between late-2006 and mid-2008 to their highest level in thirty years, fell sharply through 2009 and then regained their 2008 peak in late-2010-early 2011 (FAO 2012). The resurgence of high food prices in 2010 has generated a concern of repeating 2007-8 food crisis scenarios. In this backdrop, OECD-FAO Agricultural Outlook expects prices to

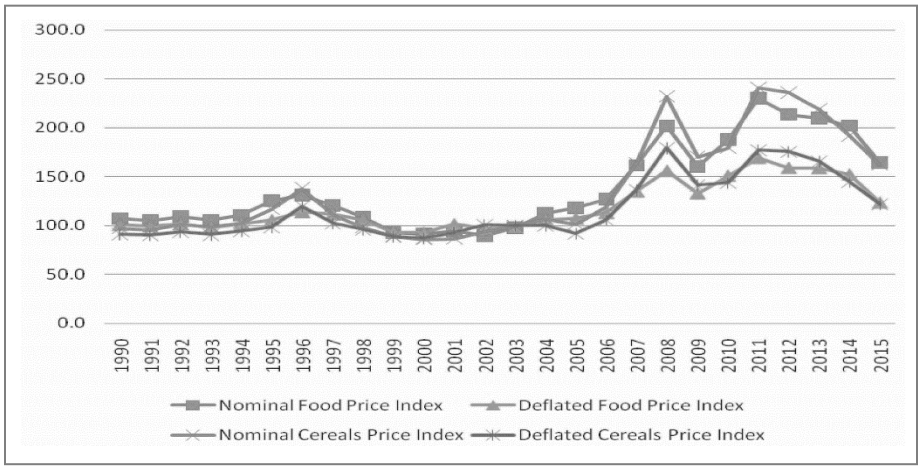
remain above their historical trend levels and to continue to be volatile in the medium term. High and volatile agricultural commodity prices are likely to persist and continue to challenge the ability of consumers, producers and governments to cope with the consequences (FAO 2012). However, in recent times, a deceleration trend in food price is witnessed since it reached its highest peak in early 2011.

Figure 1: **Trend of FAO Food Price Index**



The movement of cereal price index broadly follows similar pattern over time as that of food price index (Figure 2). The amplitude of curve representing cereal price index is relatively sharper in comparison to food price index.

Figure 2: **Trend of Food Price Index vis-à-vis Cereals Price Index**



Trends of Retail and Wholesale Prices of Rice and Wheat: Global vis-à-vis Indian Experience

International movement of price can be reflected in the behaviour of domestic price through price transmission mechanism. However, Indian economy was largely able to cushion domestic prices from the upward surge in international prices (Gustafson 2011, Dev 2010). A close scrutiny of the trend of food prices in India vis-à-vis global food prices can identify three distinct phases. In the first phase (2005 to second quarter of 2007) food prices in India followed a similar upward movement of global prices, but the rate of increase was much lower in India than globally. In the second phase (third quarter of 2007 to third quarter of 2008), even though global prices rose significantly, inflation in food prices in India in fact declined in 2007-08 as compared to 2006-07. In the third phase (fourth quarter of 2008 to recent times), global prices declined but inflation in food prices in India started increasing at a faster rate. However, the behaviour of domestic prices in retail markets experiences a similar pattern of movemement as observed in wholesale markets. In fact, retail and wholesale price movement remains more or less uniform in both rice and wheat markets. In the domestic rice market, over time movement in Patna rice prices exhibits a relatively lower than prices in other domestic markets before crisis, and suddenly rises over and above than prices in other markets after 2010 (Figures 3 and 4). Thus rice price movement in Patna shows a clear trend of volatility than other domestic markets.

Figure 3: **Trend of Retail Rice Prices in International and Domestic Market**

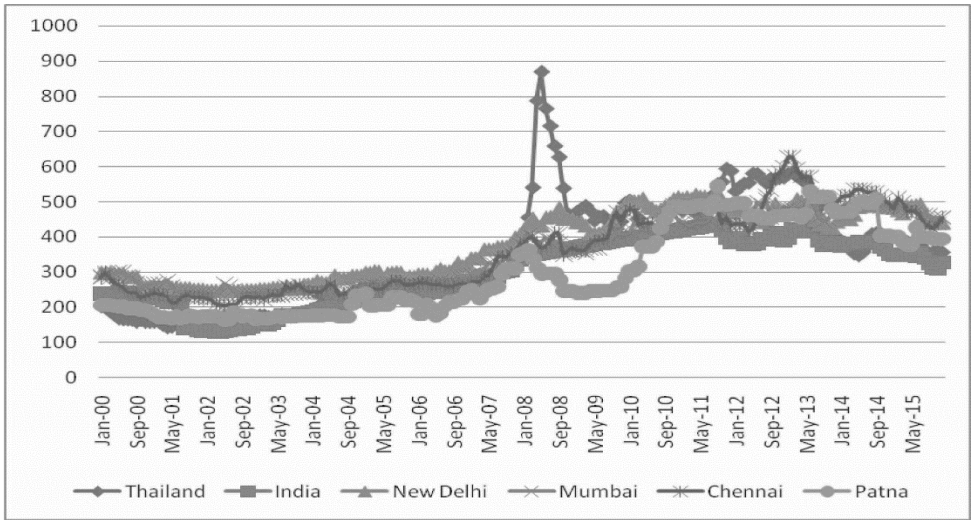
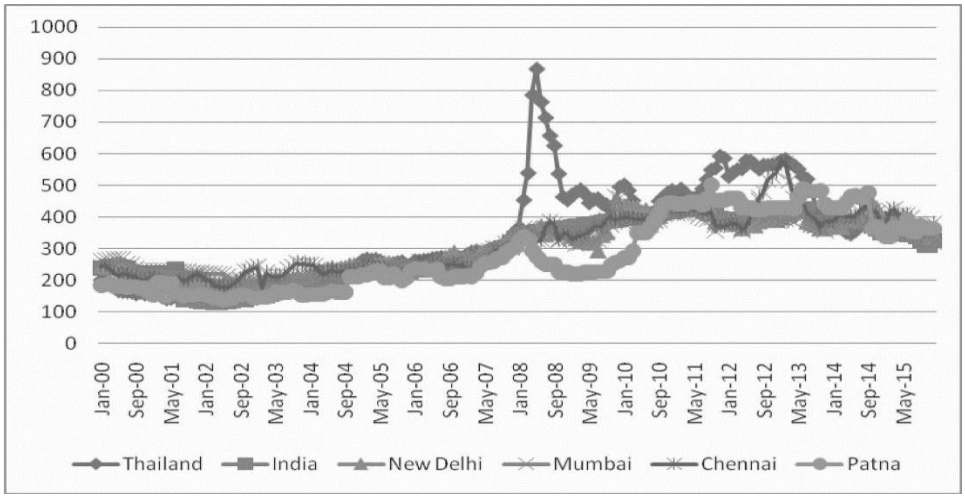


Figure 4: **Trend of Wholesale Rice Prices in International and Domestic Market**



In wheat market, a consistently upward movement of prices is observed in Chennai and Mumbai. Ups and downs of prices in other domestic markets (i.e. New Delhi and Patna) follows a similar pattern of movement as that of international prices (Figures 5 and 6).

Figure 5: **Trend of Retail Wheat Prices in International and Domestic Market**

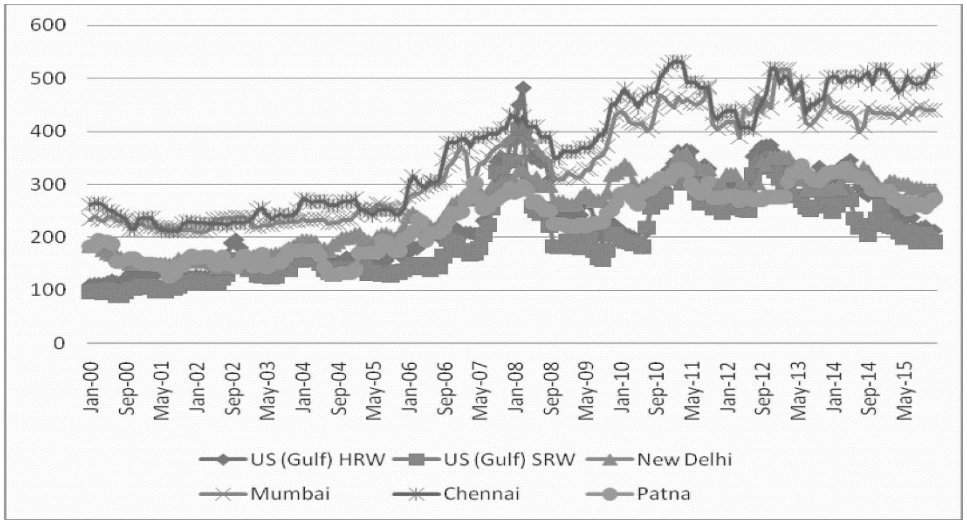
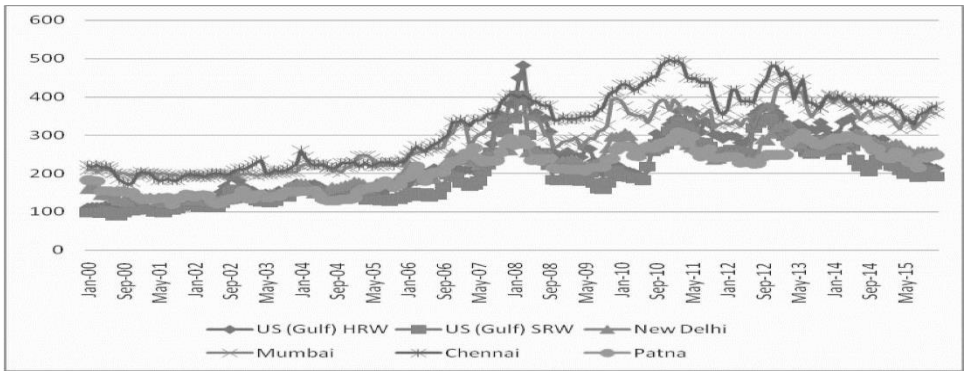


Figure 6: **Trend of Wholesale Wheat Prices in International and Domestic Market**



Trend of Volatility in International and Domestic Prices

Figures 7-10 illustrate the trend of annual CV and SDD, crude measures of historical price volatility, in rice (Figures 7-10) and wheat (Figures 11-14) in domestic and international price series for 2000-15. Overall, volatility in international rice prices is much lower than domestic prices before crisis, 2000-07. Domestic food price volatility appears to be more stable as compared to international food price volatility after global crisis, 2007. However, in wheat market, movement of international prices (whether US (Gulf) hard red winter or soft red winter variety) witnesses higher volatility than all other domestic wheat prices in the entire period of analysis, 2000-15. In fact, wheat price on soft red winter variety tends to be more volatile than hard red winter variety. A regional comparison of domestic price volatility in rice and wheat markets suggests that price behaviour in Patna and Chennai markets reflects greater volatility than Mumbai and New Delhi markets.

Figure 7: **Trend of CV in Retail Rice Prices in International and Domestic Market**

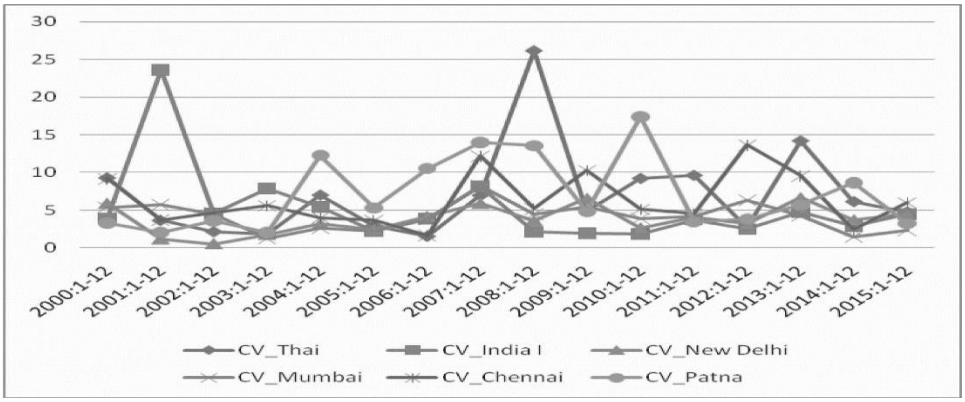


Figure 8: **Trend of CV in Wholesale Rice Prices in International and Domestic Market**

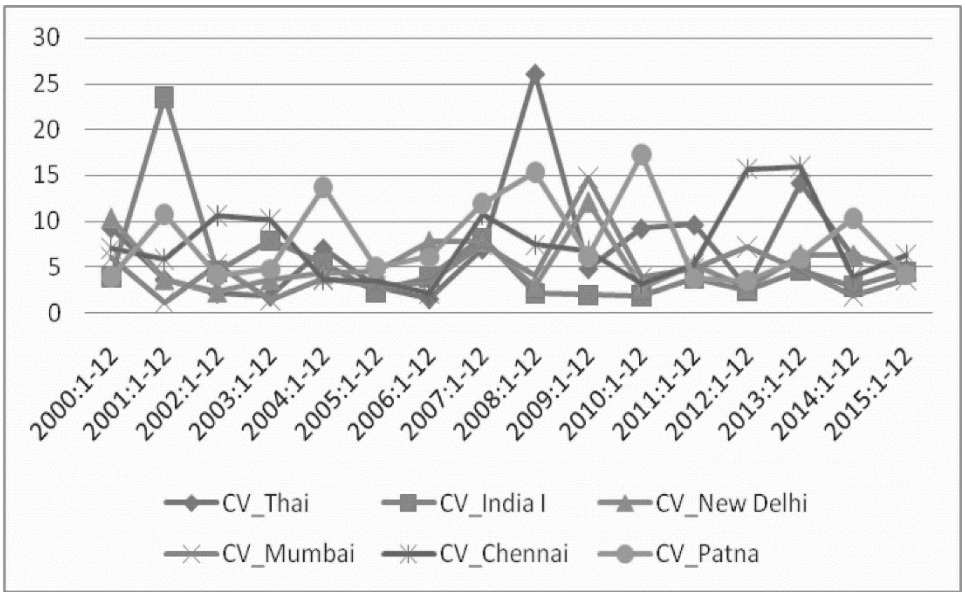


Figure 9: **Trend of SDD in Retail Rice Prices in International and Domestic Market**

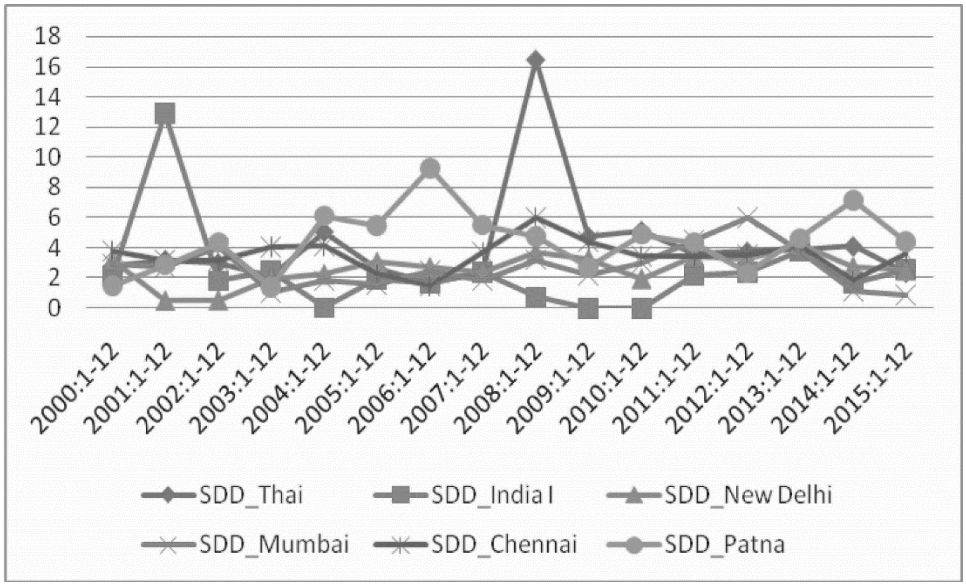


Figure 10: **Trend of SDD in Wholesale Rice Prices in International and Domestic Market**

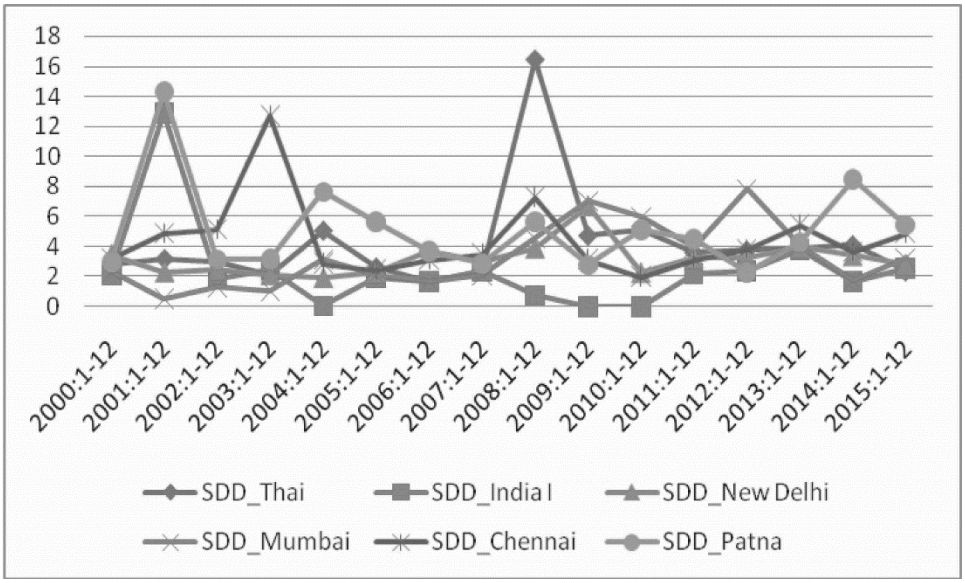


Figure 11: **Trend of CV in Retail Wheat Prices in International and Domestic Market**

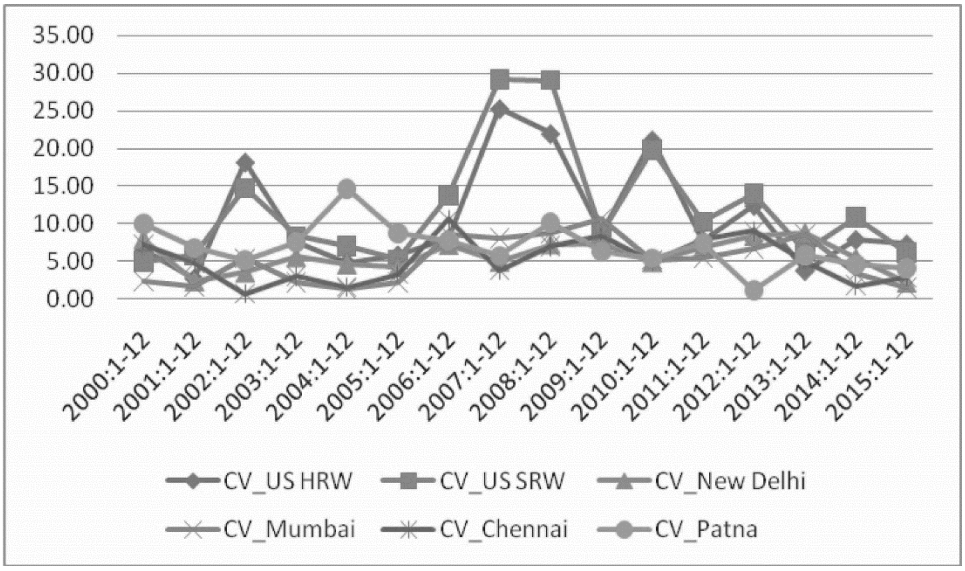


Figure 12: **Trend of CV in Wholesale Wheat Prices in International and Domestic Market**

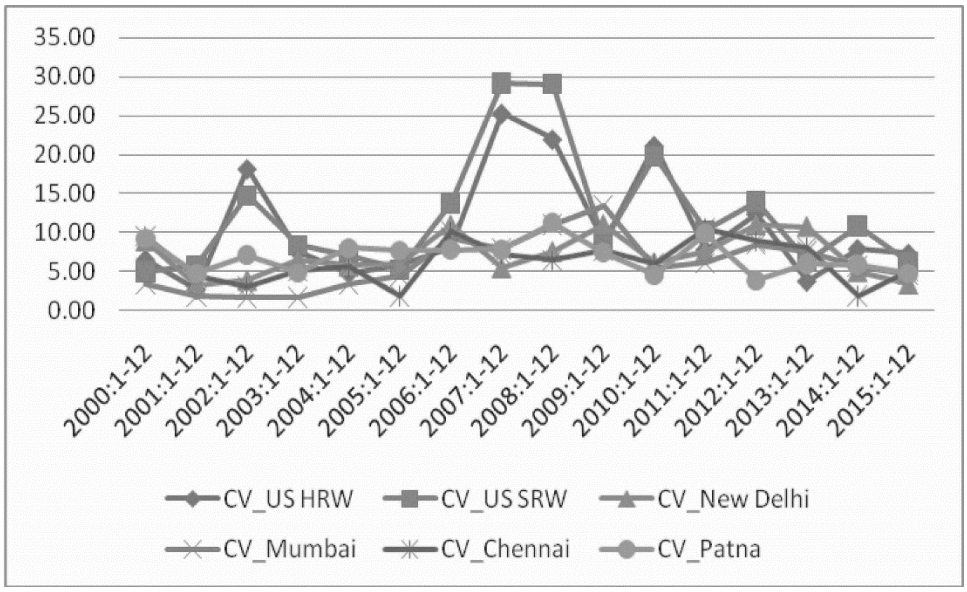


Figure 13: **Trend of SDD in Retail Wheat Prices in International and Domestic Market**

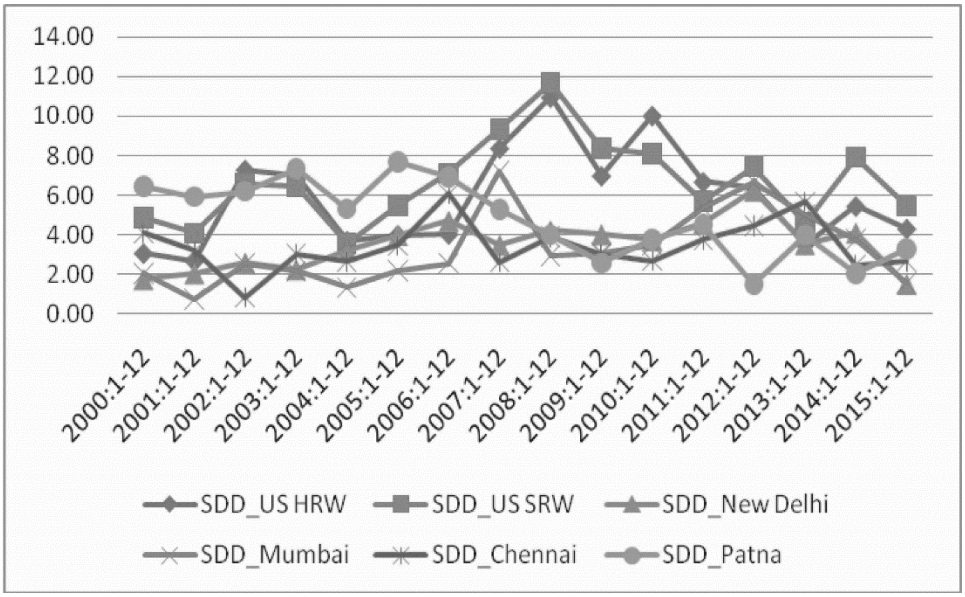
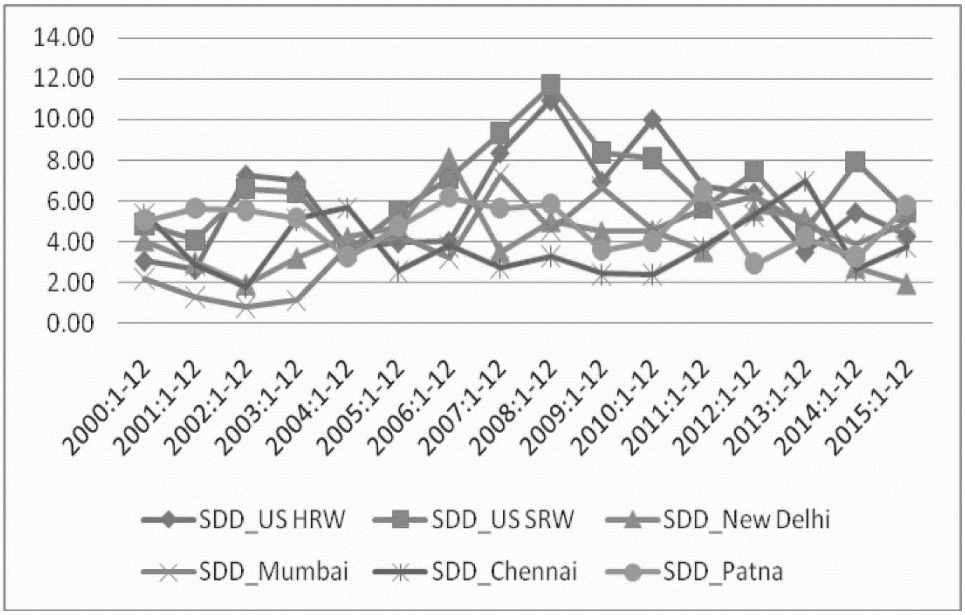


Figure 14: **Trend of SDD in Wholesale Wheat Prices in International and Domestic Market**



Tests of Equality of Means in Volatility

Empirical results based on mean equality test suggest that mean volatility of Thailand rice prices, based on CV in pre- and post-2008, differs significantly at 10 per cent level of significance. A negative estimates of t-statistic suggests an increase in volatility in second period (i.e. post 2008) in comparison to volatility in first period (i.e. pre 2008). However, no such variation is observed in Indian international rice prices. In fact, movement of rice prices in pre-crisis is found to be more volatile than post-crisis scenario. In contrast, results based on regional market prices do not support any general trend of higher volatility in the pre-crisis than post-crisis situation. In fact, SDD measure of price volatility exhibits significantly greater volatility in post-crisis scenario in New Delhi and Mumbai domestic markets.

TABLE III

TESTS OF EQUALITY OF MEAN VOLATILITY IN RICE AND WHEAT PRICES (PRE- AND POST-2008)

Price series	Retail		Wholesale	
	CV	SDD	CV	SDD
Rice price series				
International price (Thailand)	-1.841* (0.098)	-1.622 (0.143)	--	--
International price (India)	1.818 (0.111)	0.999 (0.343)	--	--
Domestic price (New Delhi)	-1.359 (0.195)	-2.376** (0.032)	0.115 (0.909)	-1.977* (0.076)
Domestic price (Mumbai)	0.180 (0.859)	-1.146 (0.275)	-1.055 (0.313)	-3.906*** (0.003)
Domestic price (Chennai)	-0.845 (0.411)	-1.117 (0.282)	-0.642 (0.531)	0.423 (0.680)
Domestic price (Patna)	-0.379 (0.710)	0.137 (0.893)	-0.325 (0.749)	0.407 (0.691)
Wheat price series				
International price (US) HRW	-0.409 (0.688)	-1.481 (0.160)	--	--
International price (US) SRW	-0.500 (0.624)	-1.436 (0.172)	--	--
Domestic price (New Delhi)	-1.346 (0.199)	-1.684 (0.114)	-1.067 (0.303)	-0.045 (0.964)
Domestic price (Mumbai)	-1.556 (0.141)	-1.540 (0.145)	-2.402** (0.030)	-2.595** (0.026)
Domestic price (Chennai)	-1.016 (0.326)	-0.511 (0.617)	-0.697 (0.497)	-0.100 (0.920)
Domestic price (Patna)	1.923* (0.075)	6.479*** (0.000)	0.427 (0.677)	1.117 (0.282)

Note: The figure is the estimated value of t statistic along with P value at two-tail test.

Unlike rice prices, the behaviour of wheat prices reflects a consistent upward trend of volatility in all international and domestic markets (except Patna market). However, the upward trend of volatility is statistically significant in only Mumbai wholesale market. On the other hand, Patna retail market witnesses a significant decelerating trend in volatilty measure over time.

Even though rice prices in Indian market is comparatively volatile in general than Thailand market (except New Delhi and Mumbai) before crisis took place, but statistical evidence does not support that they differ significantly from one

another in all the cases. However, the situation is, to some extent, different in post crisis scenario. In fact, volatility in Thailand rice prices is significantly higher than the pattern of volatility in Indian international prices. A sudden price hike in international prices results in volatility in international prices, but volatility in domestic prices do not respond at such height in all domestic markets.

TABLE IV

TESTS OF EQUALITY OF MEANS IN VOLATILITY (INTERNATIONAL AND DOMESTIC PRICES)

Price Series	Data	Retail		Wholesale	
		CV	SDD	CV	SDD
Rice price series					
Thailand and India international prices	2000-2007	-1.178	-0.224	--	--
		(0.265)	(0.828)		
	2008-2015	2.451**	2.297**	--	--
		(0.043)	(0.050)		
Thailand and New Delhi domestic prices	2000-2007	0.988	1.529	-0.834	0.419
		(0.339)	(0.148)	(0.417)	(0.681)
	2008-2015	1.947*	1.468	1.473	1.084
		(0.087)	(0.185)	(0.174)	(0.309)
Thailand and Mumbai domestic prices	2000-2007	0.139	1.126	0.323	2.368**
		(0.891)	(0.278)	(0.751)	(0.032)
	2008-2015	2.065*	1.409	1.329	0.404
		(0.072)	(0.192)	(0.210)	(0.694)
Thailand and Chennai domestic prices	2000-2007	-0.748	-0.723	-1.415	-1.502
		(0.466)	(0.481)	(0.178)	(0.171)
	2008-2015	0.866	1.035	0.509	0.791
		(0.406)	(0.330)	(0.618)	(0.448)
Thailand and Patna domestic prices	2000-2007	-1.112	-1.697	-1.837*	-1.768
		(0.289)	(0.123)	(0.087)	(0.114)
	2008-2015	0.638	0.651	0.401	0.418
		(0.533)	(0.532)	(0.693)	(0.685)
Wheat price series					
US and New Delhi domestic prices	2000-2007	1.748	2.343**	1.222	0.873
		(0.118)	(0.041)	(0.256)	(0.397)
	2008-2015	2.019*	2.721**	1.367	2.573**
		(0.078)	(0.021)	(0.201)	(0.027)
US and Mumbai domestic prices	2000-2007	2.060*	2.286**	1.980*	1.851*
		(0.069)	(0.038)	(0.078)	(0.085)
	2008-2015	1.987*	2.574**	1.403	1.679
		(0.074)	(0.024)	(0.190)	(0.127)
US and Chennai domestic prices	2000-2007	1.878*	1.868*	1.385	1.347
		(0.092)	(0.082)	(0.199)	(0.199)
	2008-2015	2.176**	3.209***	1.784	2.748**
		(0.057)	(0.010)	(0.108)	(0.015)
US and Patna domestic prices	2000-2007	0.555	-1.671	0.999	-0.180
		(0.591)	(0.129)	(0.346)	(0.860)
	2008-2015	2.281**	3.583***	1.855*	2.190**
		(0.048)	(0.005)	(0.096)	(0.050)

Note: The figure is the estimated value of t statistic along with P value at two-tail test.

In wheat market, statistical evidence suggests that there is a general tendency of higher volatility in international prices than domestic prices both in the pre and post-2008. However, difference of volatility in international and domestic market is more prominent in the post-crisis scenario.

Tests of Equality of Variances for Price Differences

To have a deeper insights into the above findings, we have considered differences in domestic and international prices for rice and tested for equality of variances of such price differences. The trend of monthly price difference in rice and wheat markets is illustrated in Figures 15-18. The movement of differences in prices reveals a sudden upward movement in the face of food price inflation in the international market in 2008. The response of domestic prices due to price transmission mechanism results in narrowing down the price differences in the successive years.

To establish statistical support for the above observations, we have tested for equality of variances of price differences by the standard F test. The empirical result with 5% level of significance is presented in Table V. In order to ensure that the estimated value of F test statisic greater than unity, we have calculated the ratio of variance of price differences in the second period (i.e. post-crisis situtation) to that of first period (i.e. pre-cisis situation). It is evident that volatility for price differences in the post-2008 is significantly higher than in the pre-crisis scenario for both rice and wheat markets.

Figure 15: **Trend of Price Differences in Retail Rice Prices in International and Domestic Market**

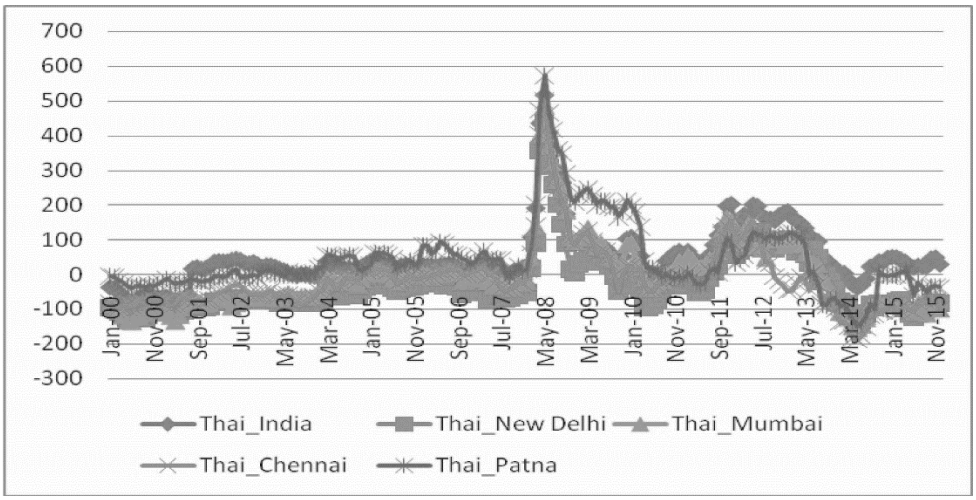


Figure 16: **Trend of Price Differences in Wholesale Rice Prices in International and Domestic Market**

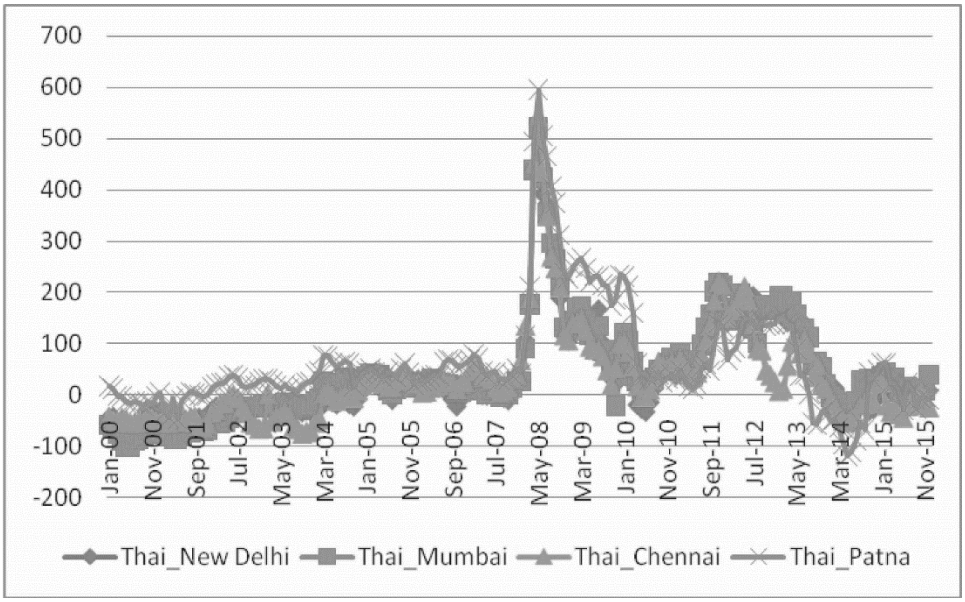


Figure 17: **Trend of Price Differences in Retail Wheat Prices in International and Domestic Market**

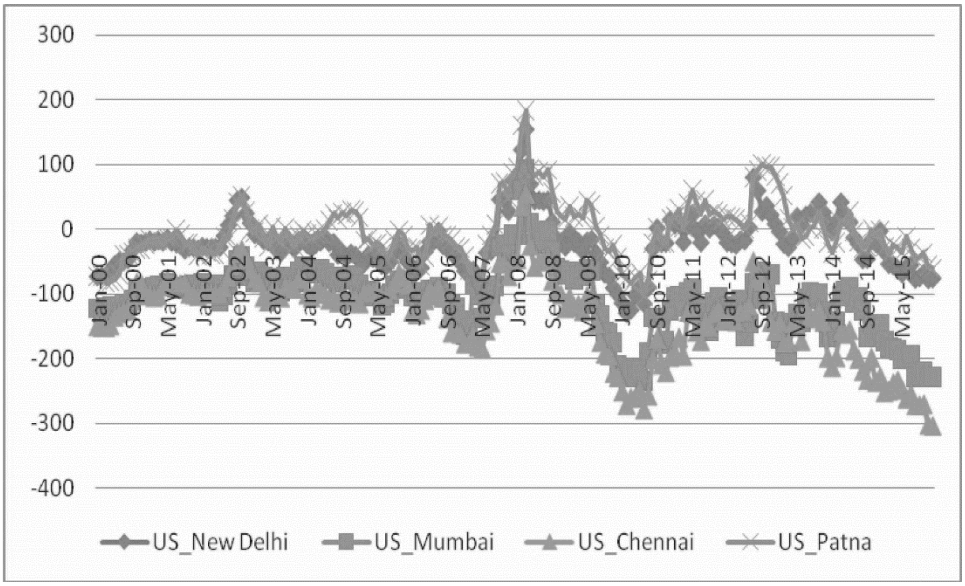


Figure 18: **Trend of Price Differences in Wholesale Wheat Prices in International and Domestic Market**

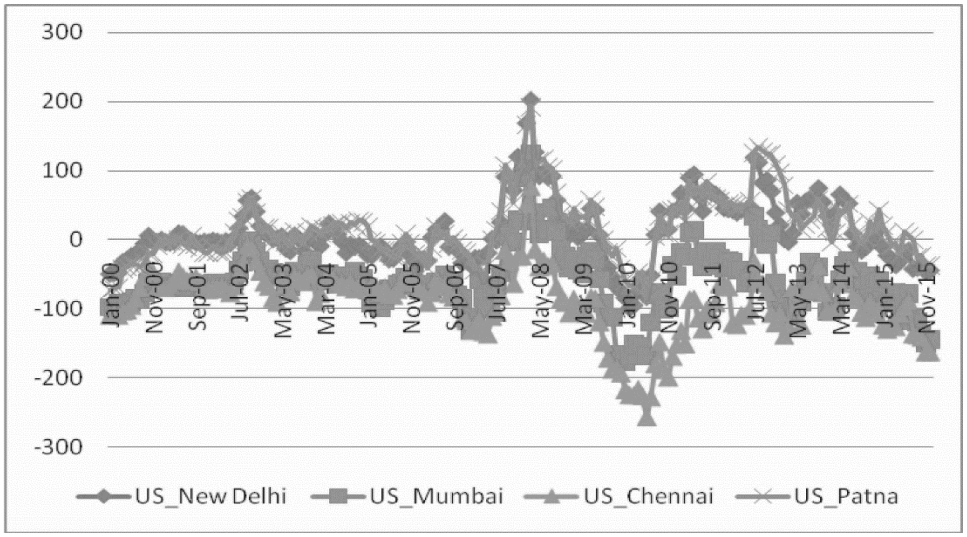


TABLE V

TESTS OF EQUALITY OF VARIANCES FOR PRICE DIFFERENCES IN PRE- AND POST-2008

Price Series	Retail	Wholesale
Rice price series		
Thailand and India international prices	7.354***	---
	(0.000)	
Thailand and New Delhi domestic prices	13.739***	15.654***
	(0.000)	(0.000)
Thailand and Mumbai domestic prices	8.152***	6.216***
	(0.000)	(0.000)
Thailand and Chennai domestic prices	12.295***	8.775***
	(0.000)	(0.000)
Thailand and Patna domestic prices	17.787***	25.124***
	(0.000)	(0.000)
Wheat price series		
US and New Delhi domestic prices	3.117***	3.914***
	(0.000)	(0.000)
US and Mumbai domestic prices	6.747***	5.004***
	(0.000)	(0.000)
US and Chennai domestic prices	5.300***	5.264***
	(0.000)	(0.000)
US and Patna domestic prices	2.435***	2.821***
	(0.000)	(0.000)

Note: The figure is the estimated value of F statistic along with P value at one-tail test.

4.2 Measurement of Pass-through Effect

This section examines the change in rice and wheat prices in domestic and international markets during the last 15 years. The chosen time period covers both pre- and post-period of rapid growth in world food prices. Conventionally, Thai Super A1 broken white rice and India 25% broken rice are considered the representative of international price in world rice market in first and second panels of Table VI respectively. Before our experience of world food price inflation, there is a visible increasing trend of Thailand and domestic rice prices: Thailand prices generally increased more rapidly than retail and wholesale prices all domestic markets. However, Thailand rice prices exhibit a declining trend of prices in the post-2008 scenario, while domestic rice prices maintain their increasing trend. It is reflected in the pass through percentage, which is observed to be negative in post-crisis situation. Considering absolute change in the transmission elasticity, the average pass through effect in post-crisis (43.5 per cent) is greater than pre-crisis situation (28.3 per cent). Analysis based on Indian international price suggests that average estimate of pass through percentage in pre-crisis situation is nearly 200 per cent less than the percentage in post crisis situation (second panel of Table VI). Estimates of transmission elasticity in most of the cases (generally above 100 per cent) reflect the less fluctuations in Indian international prices than Thailand prices.

TABLE VI

CHANGE IN INTERNATIONAL PRICE AND DOMESTIC PRICE IN RICE MARKET (PRE-AND POST-2008)

Market	Type of market	2000-07			2008-15		
		Increase in international price (%)	Increase in domestic price (%)	Pass through	Increase in international price (%)	Increase in domestic price (%)	Pass through
Thailand international price							
New Delhi	Retail	77.65	29.19	37.60	-38.22	4.28	-11.20
Mumbai	Retail	77.65	15.89	20.46	-38.22	22.19	-58.07
Chennai	Retail	77.65	24.93	32.11	-38.22	20.96	-54.83
Patna	Retail	77.65	37.59	48.41	-38.22	33.19	-86.83
New Delhi	Wholesale	77.65	34.24	44.10	-38.22	3.15	-8.24
Mumbai	Wholesale	77.65	16.66	21.46	-38.22	1.84	-4.81
Chennai	Wholesale	77.65	24.32	31.32	-38.22	13.75	-35.99
Patna	Wholesale	77.65	43.63	56.19	-38.22	33.56	-87.82
Average		77.65	28.31	36.46	-38.22	16.62	-43.47
Indian international price							
New Delhi	Retail	24.17	29.19	120.80	-5.35	4.28	-80.02
Mumbai	Retail	24.17	15.89	65.76	-5.35	22.19	-414.88

(Contd. Table VI)

Market	Type of market	2000-07			2008-15		
		Increase in international price (%)	Increase in domestic price (%)	Pass through	Increase in international price (%)	Increase in domestic price (%)	Pass through
Chennai	Retail	24.17	24.93	103.18	-5.35	20.96	-391.78
Patna	Retail	24.17	37.59	155.55	-5.35	33.19	-620.39
New Delhi	Wholesale	24.17	34.24	141.71	-5.35	3.15	-58.85
Mumbai	Wholesale	24.17	16.66	68.94	-5.35	1.84	-34.40
Chennai	Wholesale	24.17	24.32	100.64	-5.35	13.75	-257.15
Patna	Wholesale	24.17	43.63	180.56	-5.35	33.56	-627.48
Average		24.17	28.31	117.14	-5.35	16.62	-310.62

In pre-crisis scenario, international wheat prices increased 124 per cent (hard red winter) and 141 per cent (soft red winter), significantly more than rice prices (Table VII). Domestic wheat prices also registered, on average, 64 per cent increase. Accordingly, pass through effect recorded 51 (hard red winter) and 45 (soft red winter) in pre-2008, significantly higher than post-2008 situation. Like rice prices, international wheat prices showed a lower degree of pass through effect in the post-crisis scenario.

TABLE VII

CHANGE IN INTERNATIONAL PRICE AND DOMESTIC PRICE IN WHEAT MARKET (PRE-AND POST-2008)

Market	Type of market	2000-07			2008-15		
		Increase in international price (%)	Increase in domestic price (%)	Pass through	Increase in international price (%)	Increase in domestic price (%)	Pass through
US (Gulf) HRW price							
New Delhi	Retail	124.23	72.45	58.32	-32.44	-0.89	2.76
Mumbai	Retail	124.23	52.18	42.01	-32.44	22.92	-70.67
Chennai	Retail	124.23	61.56	49.55	-32.44	26.20	-80.77
Patna	Retail	124.23	58.39	47.00	-32.44	2.90	-8.94
New Delhi	Wholesale	124.23	72.45	58.32	-32.44	3.77	-11.63
Mumbai	Wholesale	124.23	57.60	46.37	-32.44	6.37	-19.63
Chennai	Wholesale	124.23	76.79	61.81	-32.44	-4.63	14.27
Patna	Wholesale	124.23	57.50	46.29	-32.44	-2.04	6.30
Average		124.23	63.62	51.21	-32.44	6.82	-21.04
US (Gulf) SRW price							
New Delhi	Retail	141.06	72.45	51.36	-22.80	-0.89	3.92
Mumbai	Retail	141.06	52.18	36.99	-22.80	22.92	-100.53
Chennai	Retail	141.06	61.56	43.64	-22.80	26.20	-114.89
Patna	Retail	141.06	58.39	41.40	-22.80	2.90	-12.72
New Delhi	Wholesale	141.06	72.45	51.36	-22.80	3.77	-16.54
Mumbai	Wholesale	141.06	57.60	40.84	-22.80	6.37	-27.93
Chennai	Wholesale	141.06	76.79	54.44	-22.80	-4.63	20.29
Patna	Wholesale	141.06	57.50	40.76	-22.80	-2.04	8.96
Average		141.06	63.62	45.10	-22.80	6.82	-29.93

4.3 Econometric Analysis of Price Transmission Mechanism

Test of Stationary

As mentioned in the methodology, we cannot apply regression analysis here as the price series relating to international and domestic markets may be non-stationary in level form. We have tested this proposition by Augmented Dickey Fuller (A.D.F) test. Results of the A.D.F test in rice and wheat markets are presented in the Table VIII.

TABLE VIII

RESULTS OF AUGMENTED DICKEY FULLER TEST

Series Name	Test in	ADF test statistic	Test in	ADF test statistic
Rice price series in log				
Thailand price	Level	-1.569 (0.497)	First Difference	-7.907 (0.000)
Indian price	Level	-0.782 (0.822)	First Difference	-10.209 (0.000)
New Delhi (retail)	Level	-0.735 (0.835)	First Difference	-19.545 (0.000)
Mumbai (retail)	Level	-0.515 (0.885)	First Difference	-19.555 (0.000)
Chennai (retail)	Level	-0.642 (0.857)	First Difference	-11.994 (0.000)
Patna (retail)	Level	-0.806 (0.815)	First Difference	-12.073 (0.000)
New Delhi (wholesale)	Level	-0.844 (0.803)	First Difference	-12.767 (0.000)
Mumbai (wholesale)	Level	-1.058 (0.731)	First Difference	-11.142 (0.000)
Chennai (wholesale)	Level	-1.134 (0.701)	First Difference	-14.220 (0.000)
Patna (wholesale)	Level	-1.008 (0.750)	First Difference	-15.138 (0.000)
Wheat price series in log				
US HRW price	Level	-2.067 (0.258)	First Difference	-10.695 (0.000)
US SRW price	Level	-2.101 (0.244)	First Difference	-10.782 (0.000)
New Delhi (retail)	Level	-1.199 (0.674)	First Difference	-11.065 (0.000)
Mumbai (retail)	Level	-0.961 (0.766)	First Difference	-13.512 (0.000)
Chennai (retail)	Level	-0.579 (0.870)	First Difference	-11.956 (0.000)
Patna (retail)	Level	-1.235 (0.658)	First Difference	-12.373 (0.000)
New Delhi (wholesale)	Level	-1.114 (0.710)	First Difference	-11.754 (0.000)
Mumbai (wholesale)	Level	-1.273 (0.641)	First Difference	-13.776 (0.000)
Chennai (wholesale)	Level	-1.067 (0.728)	First Difference	-11.965 (0.000)
Patna (wholesale)	Level	-1.146 (0.697)	First Difference	-13.290 (0.000)

Note: Figures in the parentheses represent MacKinnon (1996) one-sided p-values.

From this result, it is clear that none of the rice or wheat price series are stationary in level form and they became stationary by the operation of first

difference. To arrive at such a conclusion, we mainly compare ADF test statistic (here t-statistic) with MacKinnon critical values.

Test of Long run Relationship: Johansen Co-integration Test

ADF test reveals the existence of unit root in domestic and international price series in the level form and their first difference is found to be stationary. Alternatively, we can say that domestic and international prices of rice and wheat are integrated of the same order. In this context, co-integration technique is used to determine a stable long run relationship between two price series. The results of the Johansen method of co-integration in rice market at lag length 1[1] are presented in Table IX. The following table shows the results of co-integration rank test for the λ_{trace} and λ_{max} in rice and wheat markets. The long run cointegrating relationship is established between Thailand price and wholesale domestic rice prices (except Patna market). In fact, in the wholesale rice market, the value of trace statistic is greater than its critical value at 5% level of significance and thereby, the null hypothesis of no co-integrating vector is rejected. Now if we move to the next column then we also see that Maximum Eigen Value statistic again exceeds the critical value at 5% level. Thus, max-test also confirms our result that there exists at least one co-integration relationship between price series in Thailand and domestic wholesale rice market, and thereby they are co-integrated. In this context, an improved transmission of information exists in both domestic wholesale and international market by which markets will become efficient. In retail market, empirical results suggest a significant long-run relationship between international price and New Delhi domestic price. Unlike rice wholesale market, long run cointegrating relationship is evident in two retail markets (at New Delhi and Patna) and four wholesale markets (at New Delhi, Mumbai,[2] Chennai and Patna). The conclusion is supported by the empirical results of cointegration based on Trace statistic and Max-Eigen value statistics.

[1]Lag length has been chosen by considering two information criteria (Akaike Information Criteria and Schwarz Criteria) in Vector Autoregressive framework. Akaike Information Criteria generally agrees with other information criteria, such as Schwarz Criteria. A uniform selection of lag length 2 is justified as information criteria of most of the empirical results of VAR on domestic and international price series reaches minimum at lag 2. Results of cointegration relating to lag 2 are presented in appendix Table A.I. However, to make a comparison on short run adjustment and long run adjustment for one month lag period, we have intentionally chosen lag 1 for discussion.

[2]In Mumbai wholesale wheat market, there is a significant long-run relationship between international wheat price and domestic price in just one month of lagged terms, however, the relationship is insignificant at two months of lagged terms. In all other price series, no difference in cointegration results is observed either at one or two months of lagged terms.

Overall, long run relationships in the behaviour of prices are found robust in three cases: wheat market; wholesale price series in rice and wheat markets; and rice and wheat markets in New Delhi (both retail and wholesale).

TABLE IX

RESULTS ON JOHANSEN COINTEGRATION TEST (AT LAG 1)

Domestic Price series	Hypothesized No. of CE(s)	Eigen Value	Trace Statistic	Prob.**	Max-Eigen Statistic	Prob.**
International (Thailand) and Domestic Rice Prices						
New Delhi (retail)	None*	0.074421	15.45711	0.0507	14.69374	0.0428
	At most 1	0.004010	0.763369	0.3823	0.763369	0.3823
Mumbai (retail)	None	0.045969	9.623011	0.3109	8.941280	0.2911
	At most 1	0.003582	0.681730	0.4090	0.681730	0.4090
Chennai (retail)	None	0.058537	12.35760	0.1406	11.46088	0.1326
	At most 1	0.004708	0.896718	0.3437	0.896718	0.3437
Patna (retail)	None	0.040561	8.717754	0.3921	7.867279	0.3923
	At most 1	0.004466	0.850475	0.3564	0.850475	0.3564
New Delhi (wholesale)	None*	0.069126	14.60499	0.0678	13.61001	0.0632
	At most 1	0.005223	0.994988	0.3185	0.994988	0.3185
Mumbai (wholesale)	None *	0.075744	16.15223	0.0398	14.96562	0.0387
	At most 1	0.006226	1.186610	0.2760	1.186610	0.2760
Chennai (wholesale)	None *	0.077726	16.76478	0.0320	15.37348	0.0333
	At most 1	0.007296	1.391308	0.2382	1.391308	0.2382
Patna (wholesale)	None	0.041066	8.751814	0.3888	7.967224	0.3820
	At most 1	0.004121	0.784589	0.3757	0.784589	0.3757
International (US HRW) and Domestic Wheat Prices						
New Delhi (retail)	None *	0.073985	16.43749	0.0360	14.60431	0.0442
	At most 1	0.009602	1.833179	0.1758	1.833179	0.1758
Mumbai (retail)	None	0.058638	12.27930	0.1440	11.48115	0.1317
	At most 1	0.004192	0.798142	0.3716	0.798142	0.3716
Chennai (retail)	None	0.052425	10.94680	0.2148	10.23135	0.1972
	At most 1	0.003758	0.715447	0.3976	0.715447	0.3976
Patna (retail)	None *	0.085000	18.73299	0.0157	16.87789	0.0189
	At most 1	0.009716	1.855102	0.1732	1.855102	0.1732
New Delhi (wholesale)	None *	0.072766	16.36116	0.0370	14.35445	0.0484
	At most 1	0.010506	2.006709	0.1566	2.006709	0.1566
Mumbai (wholesale)	None*	0.066871	14.82562	0.0629	13.15023	0.0744
	At most 1	0.008779	1.675391	0.1955	1.675391	0.1955
Chennai (wholesale)	None *	0.081737	17.70013	0.0229	16.20162	0.0244
	At most 1	0.007856	1.498508	0.2209	1.498508	0.2209
Patna (wholesale)	None *	0.081317	17.54037	0.0243	16.11467	0.0252
	At most 1	0.007476	1.425700	0.2325	1.425700	0.2325

Note: * denotes rejection of the hypothesis at the 0.10 level and ** denotes MacKinnon-Haug-Michelis (1999) p-values.

Test of Short run Relationship: Vector Error Correction Model

Although there is a long run stable relationship as represented by co-integration, in the short run there may be disequilibrium. In the VEC specification, it is assumed that price deviations from the equilibrium relationship between domestic and international markets are corrected at a speed of the coefficient of error correction term. The magnitude of the error correction term (i.e. φ in our earlier empirical specification) indicates the speed of adjustment of any disequilibrium towards long run equilibrium. In our empirical results, the negative and statistically significant coefficients of the estimated error correction term (or speed of adjustment) indicate that about 4 per cent to 8 per cent variation in the world prices is eventually transmitted to the rice prices in domestic markets (first panel of Table X). In other words, large positive deviations from the cointegrating relation between the domestic and international prices for rice are significantly corrected in the following period. In fact, the lower magnitude of the terms do not pose a threat in the transmission of international price volatility in the domestic rice market. On the other hand, out of six long run relationship in the wheat market, a statistically significant coefficient is observed in four cases (second panel of Table X). The magnitude of the error coefficient terms is even lower than rice market; varies in a narrow range of 3 to 5 per cent.

TABLE X

RESULTS ON VECTOR ERROR CORRECTION METHOD (AT LAG 1)

Series Name	Speed of adjustment (φ)	Short run adjustment due to		Long run adjustment (β)
		Change in domestic price (ρ)	Change in international price (δ)	
Rice price series				
New Delhi (retail)	-0.039**	0.012	0.016	-0.636***
	(-2.162)	(0.162)	(0.411)	(-10.167)
New Delhi (wholesale)	-0.041**	0.079	0.050	-0.671***
	(-2.007)	(1.091)	(1.078)	(-9.470)
Mumbai (wholesale)	-0.059***	0.021	-0.075	-0.603***
	(-2.687)	(0.282)	(-1.416)	(-8.485)
Chennai (wholesale)	-0.081***	-0.008	-0.036	-0.681***
	(-3.099)	(-0.113)	(-0.520)	(-8.994)

(Contd. Table X)

Series Name	Speed of adjustment (φ)	Short run adjustment due to		Long run adjustment (β)
		Change in domestic price (ρ)	Change in international price (δ)	
Wheat price series				
New Delhi (retail)	-0.036**	0.200***	0.067*	-0.885***
	(-1.999)	(2.826)	(1.640)	(-8.886)
Patna (retail)	-0.039*	0.120*	0.072	-0.850***
	(-1.634)	(1.634)	(1.259)	(-8.525)
New Delhi (wholesale)	-0.044**	0.159**	0.062	-0.885***
	(-2.154)	(2.225)	(1.263)	(-8.278)
Mumbai (wholesale)	-0.029	-0.016	0.104**	-0.810***
	(-1.204)	(-0.217)	(2.022)	(-8.162)
Chennai (wholesale)	-0.024	0.134*	0.128**	-0.964***
	(-1.260)	(1.878)	(2.783)	(-9.723)
Patna (wholesale)	-0.045**	0.028	0.134**	-0.851***
	(-1.938)	(0.395)	(2.413)	(-8.358)

Note: Figures in the parentheses represent the estimated value of t-statistic.

In the co-integration equation,[3] the long run elasticity of price transmission (i.e. long run elasticity of the domestic price with respect to the international price) is measured by the magnitude of co-integration factor (i.e. β). It is evident that nearly 60 to 68 per cent of the proportional change in the international rice price actually transmitted to the domestic prices in the long run (first panel of Table X). The wheat market is more vulnerable in comparison to rice market as a significant proportion of 81 to 96 percentage change in international wheat price transmitted to domestic prices in the long run (second panel of Table X).

The coefficient on lagged change in world price (δ)[4] exhibits a short-run elasticity of the domestic price relative to the world price in one month after a one per cent shock in international price. The estimated values follow our

[3]The same cointegrating equation is also reproduced in the VECM estimation output. Thus long run adjustment terms in the last column of the tables, as specified in the cointegrating equation, are reported here to make effective comparison of short run vis-à-vis long run adjustment.

[4]In the framework of two lag structure of VECM, the coefficient on lagged change in world price (δ) exhibits a short-run elasticity of the domestic price relative to the world price in one month and two months after a one per cent shock in international price. Results are presented in the appendix Table A.II.

expected sign, i.e. $0 < \delta < \beta$, i.e. magnitude of short run adjustment is lower than long run adjustment. In addition, the autoregressive term of the lagged change in the domestic price (ρ) lies in the expected range, i.e. $-1 < \rho < 1$. Overall, it is suggested that VECM results are consistent with the earlier results on co-integrated domestic and international price series. Thus short run disequilibrium is corrected in the long run and price movement tends to follow long run equilibrium steady state path.

V. CONCLUSION

This paper analyses the trend of volatility in the prices of two important cereal commodities (viz. rice and wheat) in the world market vis-à-vis Indian market. In addition, this paper explores the mechanism of transmission of prices in understanding the process of volatility spillover from international to domestic market. However, the main findings of the paper can be summarised as follows:

- Cereal prices broadly follow similar pattern of movement over the years as that of food prices. The behaviour of domestic prices in retail markets experiences a similar pattern of movemement as observed in wholesale markets.
- In the domestic rice market, movement in Patna rice prices over time exhibits relatively lower prices than other domestic markets before crisis, and suddenly rises over and above the prices in other markets after 2010. Thus rice price movement in Patna shows a clear trend of volatility compared to other domestic markets. In wheat market, a consistently upward price movement is observed in Chennai and Mumbai. Ups and downs in prices in other domestic markets (i.e. New Delhi and Patna) follows a similar pattern of movement as observed in international prices.
- Volatility in international rice prices was much lower than domestic prices before the global crisis in 2007-08. Domestic price appears to have become more stable compared to international prices after the global crisis. However, in the wheat market, movement of international prices

witnessed higher volatility compared to domestic wheat prices in the entire period of analysis, 2000-15.

- International market exhibits a declining trend in rice prices in the post-2008 scenario, while domestic rice prices maintain their increasing trend. It is reflected in the pass-through percentage, which is observed to be negative in the post-crisis situation. Like rice prices, international wheat prices showed a lower degree of pass-through effect in the post-crisis scenario.
- Results of stationarity test suggest that domestic and international prices of rice and wheat are integrated of the same order. From the cointegration results, it is evident that long run relationship between domestic and international prices is more robust in wheat market than rice market. However, large positive deviations from the cointegrating relationship between domestic and international prices for rice are significantly corrected in the short run. The magnitude of the error correction in the wheat market is even lower than that in the rice market.

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Appendix

Table A.I: Results on Johansen Cointegration Test (at lag 2)

Domestic Price series	Hypothesized No. of CE(s)	Eigen value	Trace Statistic	Prob.**	Max-Eigen Statistic	Prob.**
International (Thailand) and Domestic Rice Prices						
New Delhi (retail)	None*	0.065259	13.61820	0.0940	12.75485	0.0854
	At most 1	0.004558	0.863344	0.3528	0.863344	0.3528
Mumbai (retail)	None	0.042352	8.989146	0.3664	8.179044	0.3608
	At most 1	0.004277	0.810102	0.3681	0.810102	0.3681
Chennai (retail)	None	0.052768	11.42907	0.1864	10.24597	0.1963
	At most 1	0.006240	1.183100	0.2767	1.183100	0.2767
Patna (retail)	None	0.033083	7.158170	0.5593	6.358510	0.5676
	At most 1	0.004222	0.799660	0.3712	0.799660	0.3712
New Delhi (wholesale)	None*	0.066854	14.33247	0.0743	13.07755	0.0763
	At most 1	0.006618	1.254927	0.2626	1.254927	0.2626
Mumbai (wholesale)	None*	0.064707	13.91183	0.0854	12.64322	0.0888
	At most 1	0.006690	1.268605	0.2600	1.268605	0.2600
Chennai (wholesale)	None *	0.073139	16.12420	0.0402	14.35483	0.0484
	At most 1	0.009318	1.769372	0.1835	1.769372	0.1835
Patna (wholesale)	None	0.036954	7.921270	0.4738	7.116644	0.4755
	At most 1	0.004248	0.804627	0.3697	0.804627	0.3697
International (US HRW) and Domestic Wheat Prices						
New Delhi (retail)	None*	0.065808	14.61284	0.0676	12.86589	0.0822
	At most 1	0.009201	1.746957	0.1863	1.746957	0.1863
Mumbai (retail)	None	0.045758	9.546556	0.3172	8.852353	0.2987
	At most 1	0.003666	0.694204	0.4047	0.694204	0.4047
Chennai (retail)	None	0.046074	9.541669	0.3176	8.915038	0.2933
	At most 1	0.003310	0.626631	0.4286	0.626631	0.4286
Patna (retail)	None *	0.074923	16.06771	0.0410	14.71909	0.0423
	At most 1	0.007110	1.348612	0.2455	1.348612	0.2455
New Delhi (wholesale)	None *	0.067846	15.83266	0.0445	13.27870	0.0711
	At most 1	0.013422	2.553950	0.1100	2.553950	0.1100
Mumbai (wholesale)	None	0.055088	12.37323	0.1399	10.70942	0.1694
	At most 1	0.008765	1.663804	0.1971	1.663804	0.1971
Chennai (wholesale)	None*	0.068401	14.62955	0.0672	13.39128	0.0683
	At most 1	0.006530	1.238277	0.2658	1.238277	0.2658
Patna (wholesale)	None *	0.075756	16.31999	0.0375	14.88922	0.0398
	At most 1	0.007542	1.430770	0.2316	1.430770	0.2316

Table A.II: Results on Vector Error Correction Method (at lag 2)

Series Name	Speed of adjustment (φ)	Short run adjustment due to				Long run adjustment (β)
		Change in domestic price ($\rho 1$)	Change in domestic price ($\rho 2$)	Change in international price ($\delta 1$)	Change in international price ($\delta 2$)	
Rice price series						
New Delhi (retail)	-0.033*	0.007	-0.052	0.007	0.029	-0.654***
	(-1.802)	(0.096)	(-0.706)	(0.170)	(0.655)	(-9.694)
New Delhi (wholesale)	-0.044**	0.076	0.089	0.048	-0.013	-0.670***
	(-2.114)	(1.041)	(1.198)	(0.889)	(-0.243)	(-9.505)
Mumbai (wholesale)	-0.0485**	0.0192	-0.133*	-0.075	0.036	-0.630***
	(-2.225)	(0.260)	(-1.802)	(-1.226)	(0.576)	(-8.033)
Chennai (wholesale)	-0.081***	-0.010	0.040	-0.041	-0.019	-0.679***
	(-2.964)	(-0.150)	(0.547)	(-0.515)	(-0.234)	(-8.936)
Wheat price series						
New Delhi (retail)	-0.034*	0.210**	-0.056	0.069*	0.005	-0.897***
	(-1.835)	(2.854)	(-0.777)	(1.646)	(0.121)	(-8.525)
Patna (retail)	-0.0346	0.133*	-0.147**	0.084	-0.012	-0.873***
	(-1.401)	(1.807)	(-2.004)	(1.427)	(-0.212)	(-8.206)
New Delhi (wholesale)	-0.052**	0.154**	0.090	0.060	-0.028	-0.872***
	(-2.366)	(2.104)	(1.244)	(1.191)	(-0.548)	(-8.150)
Chennai (wholesale)	-0.018	0.141*	-0.113	0.128***	0.016	-0.991***
	(-0.940)	(1.908)	(-1.571)	(2.734)	(0.342)	(-9.033)
Patna (wholesale)	-0.045*	0.034	-0.029	0.138***	-0.021	-0.861***
	(-1.860)	(0.464)	(-0.399)	(2.418)	(-0.370)	(-8.271)

Note: Figures in the parentheses represent the estimated value of t-statistic.