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Commodity market integration and price transmission: Empirical evidence from India

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Abstract. *In the era of globalization markets are connected to each other not only to compete domestic products with international products to increase economic stand but also export the required products. Therefore, in the recent years markets are more vibrant and transparent in integration with each other. Over the last couple of years, it has been seen that commodity prices have increased and remained highly volatile not only in international market but in India. Therefore, this paper examines the market integration and price transmission in India using the time series techniques of cointegration and vector error correction models. The study finds that there is both short-run and long-run relationship between domestic commodity index (all commodity index, energy index and metal index) prices and international commodity index (all commodity index, energy index and metal index) prices. But, there is no relationship between domestic agriculture index price and international agriculture index price. The study also finds that except the agriculture index price, the change in domestic commodity index (all commodity index, energy index and metal index) prices are due to the change in international commodity index (all commodity index, energy index and metal index) prices.*

Keywords: market integration, transmission, cointegration, causality and volatility.

JEL Classification: C5, Q11, Q18.

1. Introduction

In the era of globalization, international markets are connected to each other not only to compete domestic commodities with international commodities but also export the required products to other countries. Therefore, in the recent years markets are more vibrant and transparent in integration to each other. Over the last couple of years, it has been seen that commodity prices have increased and remained highly volatile in India. Therefore, it attracts to the policy maker, researcher and analysts to find out the factors behind price rise in India. From the existing literatures, we found several reasons. Commodity prices rose since 2002 reflect the significant changes in demand-supply imbalances, increase in biofuels demand, rise in oil prices and also due to speculative transactions in commodity derivatives in the global market (UNCTAD, 2010). The rise and fall in international prices tend to get transmitted from the international market to the domestic markets in an open trade environment (Rajmal and Mishra, 2009).

India is one of the major emerging economies in the world but yet only some sectors in India are integrated with the international markets. Rajmal and Mishra (2009) said that with the gradual opening up of the economy, international prices have started to play a key role in impacting domestic inflation in India. The extent to which the international price movements are reflected in domestic prices have long been a matter of interest in international economics. Hence, against the above backdrop, this paper attempts to explore the nature and extent of impact of international prices on the domestic prices in India. The reminder of the paper is organized as follows. Section 2 gives the commodity market integration. Section 3 analyse the price transmission. Section 4 gives the review of literature both for India and other countries. The methodology and data are analysed in the Section 5. In Section 6, we have analysed the estimated results. The last Section7, gives the conclusion of the study.

2. Commodity Market Integration(1)

The term 'market integration' has been variously used in different fields of research. Market integration is defined as the degree of price transmission between two, either vertically or spatially, related markets. The operational definition of market integration is known as the law of one price (LOOP) - identical products are sold at a uniform price across different markets. Homogeneous commodities follow the law of one price (Monke and Petzel, 1984). If the LOOP holds for a product in all markets, then it would be characterized as an integrated market. In the domestic economy, if LOOP holds, then domestic market integration exists (Bradford and Lawrence, 2004). In the period of globalization, commodity markets around the world have been integrated within as well as across boundaries. At the same time, deregulation in market has led to removal of trade restrictions, which is one of the pre-requisite for market integration. Commodities are now more mobile across national boundaries with the development of technologies and communication systems.

Lack of integration is referred to as 'segmentation'. A market is geographically segmented if the location of the buyer and seller influences the terms of transaction in a substantial way (that is, by more than marginal cost of physically moving the goods from one location to another). A perfectly competitive market should be fully integrated (Knetter and Goldberey, 1996). The premise of full price transmission and market integration corresponds to those of the standard competition model. In a frictionless undistorted international, the LOOP is supposed to regulate spatial price relations (Conforti, 2004). According to Stigler (1969), a market is in the law of one price (LOOP) when “the area within the price of a commodity tends to uniformity, allowance being made for transportation costs”. Based on this definition, there exists a large volume of empirical literatures investigate the market integration by analyzing price relations.

Like financial markets, commodity market integration has vital importance due to several reasons. If two regions are integrated, then it is more profitable for producers to sell in the region where goods are more expensive. The movement will continue till prices equate across regions.

Geographically, separated markets are spatially integrated if goods and information flow freely among them and, as a result, the effects of price changes in one market are transmitted to another market’s price.

Measurement of market integration can be viewed as basic data for developing an understanding of how specific markets work (Ravallion, 1986). Integrated markets do not necessarily imply efficient spatial allocations (Knetter and Slaughter, 1999). In order to understand the long-run market segmentation, we need to study price details market wise; product by product. Deviation in the LOOP is not merely because of product differentiation. Palaskas and Barbara (1993) attempt to answer the question of how markets work by evaluating the behaviour of prices of staple agricultures and then by explain the price behaviour with reference to market institutions.

3. Price transmission(2)

Broadly, the commodity market integration can be categorized into three dimensions – nationally, regionally and globally. From an alternative perspective, commodity market integration could take place horizontally and vertically. In the horizontal integration, inter-linkages occur among domestic commodity market segments, while vertical integration occurs between domestic markets and international/regional commodity markets (USID, 1998). Domestic market integration entails horizontal linkages of various regional markets.

The issue of price transmission has a long history in the economic literature, surveyed by Meyer and Cramon-Taubadel (2004). In simple term, price transmission is a change in one price that causes another price change. Generally, it is measured in terms of the transmission elasticity, defined as the percentage change in the price in one market given a 1% change in the price in another market.

The asymmetric price transmission exists when the adjustment of prices is not homogeneous with respect to characteristics, external or internal to the system. In the economic literature, asymmetric price transmission caught attention because of two reasons. First, its presence is not in line with predictions of the canonical economics theory (e.g., perfect competition and monopoly), which expects that under some regularity assumptions (such as non-kinked), convex/concave demand function) downstream responses to upstream changes should be asymmetric in terms of absolute size and timing. Secondly, asymmetric price transmission is important from the welfare point of view, that means, welfare redistribution from agents downstream to agents upstream and it has serious political and social consequences (Wlazlowski, 2003, pp. 1-25).

Broadly, the price transmissions are categorized into three – vertical, spatial and cross-commodity integration. *Vertical Price Transmission*- means an interaction between prices at different stage. It can be characterized by degree (of completeness of pass through of price change), speed, and type of price adjustments through the supply chain. Such changes are usually represented as responses to shocks at some points in the chain.

According to Fackler and Goodwin (2001, p. 973), an economic market is the spatial area 'within which the price of a good tends toward uniformity, allowance being made for transportation costs'. Therefore, when spatially separated markets are considered, price transmission analysis plays a crucial role in trying to assess how efficiently integrated they are, i.e., to which extent rational arbitrage operates. Under the spatial integration, most of the studies concentrate on the LOOP. The *cross commodity price transmission* – it is the price transmission from one commodity to another commodity.

4. Review of literature on market integration and price transmission

The literature on the market integration and price transmission are vast. They have many dimensions in terms of commodities involved, types of integration and techniques adopted.

There large numbers of research work are available on market integration and price transmission both for spatial and vertical. Most of the studies on the price transmission are examined within the context of the LOOP (cited by Baffes, 1991). For example, Esfahani (2006) examined the impact of LOOP in the Chinese wholesale agriculture markets. He found that the LOOP did not prevail in most of these markets. Kaabia et al. (2002) said that in the long-run, price transmission was perfect and any supply or demand shocks were fully transmitted to all prices in the system. In the short run, the analyses suggested that the higher degree of horizontal concentration among retailers allowed them to have market power. Some of the studies in the context of market integration include Ravallion (1986), Sexton et al. (1991), Palaskas and Harris (1993), Zanias (1993), Gardner and Brooks (1994) and Blauch (1997).

There are some studies on the spatial market integration especially with respect to international market. Dawson and Dey (2002), Choi and Kalas (2008), Ghosh (2003), Badiane and Shively (2003), Zahid et al. (2007) etc. examined the spatial market integration. Dawson and Dey (2002) found that rice markets in Bangladesh were perfectly integrated with each other. In a similar way, Choi et al. (2008) found a long-run relationship between chick pea and green gram. Ghosh (2003), found a strong evidence of spatial integration of the regional wheat markets. He also finds the long-run spatial integration in the regional markets. Badiane and Shively (1997) found that reductions in local prices and price variance following the introduction of economic reforms in 1983 could be traced to both local and central market forces. But those differences in the degree of market integration had important implications for long-run changes in transport costs and the evolution of prices in outlying markets.

Zahid et al. (2007) said that the Lahore-Gujranwala and Lahore-Faisalabad markets were perfectly integrated with each other in the long-run. The rationale behind those integrated markets was better and direct road and rail links, common socio-economic cultures, better flow of information between those markets.

Few studies in the context of vertical integration include Bakucs et al. (2013) for milk, and Goetz et al. (2008) of citrus export. Bakucs et al. (2013) said that price transmission is asymmetric in both long-run and short-run. Goetz et al. (2008) said that the evidence of positive asymmetry in price transmission, led to exporters' profit increased at the expense of grapefruit growers.

In theory, spatial price determination models suggest that if two markets are linked by trade in a free market regime, excessive demand or supply shocks in one market will have an equal impact on price in both markets. The implementation of import tariffs, in general, will allow international price changes to be fully transmitted to domestic markets in relative terms. Thus, a proportional increase in international price will result in an equal proportional increase in the domestic price, at all points in time provided that tariff levels remain unchanged.

High transfer costs and marketing margins hinder the transmission of price signals as they prohibit arbitrage. As a result, changes in international market prices are not fully transmitted to domestic prices, resulting in economic agents adjusting (if at all) partly to shifts in international supply and demand (Sexton et al., 1991; Badiane and Shively, 1998). Non-competitive behaviour such as that is considered in pricing-to-market models (Dornbush, 1987; Froot and Klempeter, 1989; Krugman, 1986) can hinder market integration.

Majority of the studies on price transmission and market integration uses different time-series techniques. The development of these techniques (such as cointegration and error correction models) has become the standard tool for analyzing spatial market relationships, replacing the earlier empirical tools (such as the bivariate correlation coefficient and regressions). The debate on the application of methodology for testing of market integration and price transmission has a relatively long history starting with Harriss (1979). Blauch (1997) provides a review of the debates and examines the statistical performance of econometric tests for market integration. In brief, linear tests for market integration and price transmission are regarded of as crude and inappropriate (Blauch, 1997; McNew, 1996; McNew and Fackler, 1997; Fackler and Goodwin, 2002 and Barrett and Li, 2002).

International Bank (2008) pointed out that the pass-through of rise of global prices don't translate into an immediate and proportionate rise in domestic price levels but due to various factors such as a weak dollar, domestic infrastructure and price stabilization policies. On the other hand, FAO (2008) indicates that the large increases in agriculture and fuel prices threaten macroeconomic stability and overall growth, especially low-income, net-importing countries. However, it implies that government policies designed to avoid large domestic price shocks. The depreciation of the US dollar against many currencies tends to reduce transmission of international market prices to domestic prices.

Most of the studies on price transmission and market integration are commodity specific (rice, wheat, milk, agricultural products etc.). For example, studies like Moghaddasi (2009), Bakhshoodeh and Sahraeiyan (2006) examined the price transmission in agricultural markets for Iran. Moghaddasi (2009) finds that price transmission according to Houck approach in pistachio market is asymmetric. Bakhshoodeh and Sahraeiyan (2006) find that long-run market integration among local markets of products such as rice and wheat. Whereas Iran's major agricultural product markets were not found integrating with international markets in the long run. Government intervention was recognized as the major impediment to domestic and international market integrations.

Rajmal and Mishra (2009) said that while domestic and international agriculture prices had moved in the same direction particularly in the current decade but the agriculture prices in India had remained lower than international prices in terms of absolute levels, percentage variations as well as volatility. There was also evidence of limited pass-through from international agriculture prices to domestic agriculture prices in India. They pointed out that the reason for limited pass-through lied in the fact that agriculture prices in India were predominantly driven by the domestic factors.

The issue of price transmission and market integration with respect to rice was also examined (see Sonogo (2008) of Nepal with India, Weber and Lee (2006) for US and Mixico, Dawson and Dey (2002) for Bangladesh, Jha et al. (2005) of India). Sanogo (2008) found that the rice markets of the hinterland were poorly integrated with the regional market of Nepalgunj. In contrast, price fluctuations were transmitted both in the short and medium-term across the India-Nepal border between Nepalgunj and the Indian border districts of Rupedia and Jogbani.

Jha et al. (2005) said that market integration was far from India due to excessive government interference. Acharya et al. (2012) find no cointegration between domestic and international rice prices. Delhi wholesale wheat prices appeared to be cointegrating with international wheat prices. There was long-run equilibrium relationship between international and domestic wheat prices at different levels of markets.

From the above literature review, we found several studies on the market integration and price transmission both spatial and vertical. However, the majority of studies like; Maghaddasi (2009), Esfahani (2006), Sonogo (2008), Rajmal and Mishra (2009), Dawson and Dey (2002), Jha et al. (2005), Zahid et al. (2012), Ghosh (2003), Acharya et al. (2012), Bakucs et al. (2013) have concentrated on agricultural commodities. But there are very rare such studies which have examined a group of commodities like the combination of agriculture, metals and energy prices. Moreover, a very less number of studies are available in an emerging country like India. Therefore, in this paper we made an attempt to empirically investigate the market integration and price transmission between international market and domestic market in India.

5. Data and methodology(3)

To examine the market integration and price transmission, we have constructed commodity price indices using both international and domestic prices. We have collected the wholesale prices of cereals, sugar, edible oil, cotton, rubber and plastic products, aluminium, metal products, other non-ferrous metals, coal and mineral oil prices. All these commodities are categorized into three groups - agricultural (cereals, sugar, edible oil, cotton and rubber and plastic products), metal (aluminium, metal products and other non-ferrous metals) and energy (coal and mineral oil price). The international commodities prices are collected from the international monetary fund (IMF). The domestic commodities price sub-indices are collected from the Reserve Bank of India (RBI) and then we have constructed the final index. The details of construction of commodities price indices are reported in the Appendix Table A1.

The market integration and price transmission are examined using the time series techniques of cointegration test, vector error correction model (VECM) and causality test. The details of the models are described in the bellow.

Before we examine any linkage between variables, we proceed to check the stationarity of selected data series using the unit root test.

A simple first order autoregressive process can be written as:

$$Y_t = \mu_0 + \mu_1 t + \alpha Y_{t-1} + \varepsilon_t. \quad (1)$$

Where Y_t is the stochastic process, and μ_0, μ_1 and α are parameters. Here, t is the time period and ε_t is a random error term, with white noise properties of zero mean, constant variance and the zero covariance. Here, μ_0 is called the drift parameter or constant or intercept term and the nature of the time series in the equation (3.1) depends on the parameter values. If $\mu_1 \neq 0$ and $|\alpha| < 1$, then Y_t follows a deterministic trend. The autoregressive component, αY_{t-1}, means that there may be short run deviations, but the series will return to trend eventually. This series is called a trend stationary (TS) process, as the residuals from the regression Y_t on a constant and a trend will be stationary. If $\mu_0 = 0$, $\mu_1 = 0$ and $\alpha = 1$, then the series is called a simple random walk, a unit root process. And if $\mu_0 \neq 0$, $\mu_1 = 0$ and $\alpha = 1$, the series is said to follow a random walk with drift parameter. A stochastic process becomes stationary after the first difference is called a difference stationary process. Likewise, any time series, which becomes stationary after de-trending is called a TS process.

Several tests have been developed for testing non-stationarity, more popularly known as unit root, in time series. These include the Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests to check the presence of unit root in the time series. These tests are necessitated when a time series is non-stationary because the usual t-test is inappropriate to test the null hypothesis, $\alpha = 1$, in equation (1). Now we discuss each type of unit root test in the following sections.

Augmented Dickey-Fuller test

The Dickey-Fuller test says that in the equation (1), the first order difference equation has a unit root. Specifically, assuming the absence of trend term in equation (1), the modified form will be as the equation (2):

$\Delta Y_t = \mu_0 + \delta\, Y_{t-1} + \varepsilon_t$. (2)

Where $\Delta Y_t = Y_t - Y_{t-1}$. Here the null hypothesis is the $\{Y_t\}$ process has a unit root, i.e. H_0: $\delta = \alpha - 1$. Since $-1 \leq \alpha \leq 0$, it follows that $-2 \leq \delta \leq 0$.

More generally, if the above equation follows a p^{th} order autoregressive process, then it is called Dickey-Fuller test. But if it follows both p^{th} and q^{th} order of both autoregressive and moving average processes [ARIMA (p,q)], this extended Dickey-Fuller test is called augmented Dickey-Fuller test. Specifically, if the time series follows AR(p), it can be represented as,

$Y_t = \mu_0 + \sum_{i=1}^{p} \alpha_i Y_{t-1} + \varepsilon_t$. (3)

After the mathematical manipulation, equation (3) can be written as:

$\Delta Y_t = \mu_0 + \delta y_{t-1} + \sum_{i=2}^{p} \beta_i \,\Delta y_{t-1+1} + \varepsilon_t$ (4)

Where $\delta = -(1 - \sum_{i=1}^{p} \alpha_i)$ and $\beta_i = \sum_{j=i}^{p} \alpha_j$.

Equation (4) is also recommended if the residuals sequence, $\{\varepsilon_t\}$ in equation (2), is not a white noise, for example, when ε_ts are auto correlated. There are different forms of DF and ADF tests, which are possible by including trend terms in equation (2) and (4), and also excluding drift (intercept or constant) term, μ_0 from these equations. DF test is a special case of ADF test when p = 1. To test the significance of δ in equations (2) and (4), the usual Student's t-statistics critical values cannot be used but τ-statistics are made available under alternative assumption of drift, trend, sample size and level of significance. They are abbreviated as τ (no drift and no trend), τ_μ (only drift) and τ_τ (with both drift and trend). DF test has also provided the critical F-test values, known as Φ_1, Φ_2, and Φ_3 for pair-wise joint tests of significance for μ_0 and μ_1. Thus, the null hypothesis that $\delta=0$ can be rejected if the computed t value for the coefficient δ is greater than the critical τ-value in absolute magnitude. It has been shown that the same DF test critical values are valid for the ADF test as well.

Phillips-Perron test

One of the important assumptions of DF test is that the error terms are uncorrelated, homoscedastic as well as identically and independently distributed (iid). Phillip and Perron (1988) have modified the DF test, known as PP test, which can be applied when the above properties are not valid. The PP test has been shown to follow the same critical values as that of DF test; but has greater power to reject the null hypothesis of unit root. However, it cannot reject the null hypothesis when the error series follows a negative moving average process. In such situation, it is recommended to use the DF test rather than the PP test.

Johansen Cointegration test

In the above equation (5), if both variables are *I(1)*, Johansen cointegration test are conducted. Consider a VAR with k[th] lags containing these variables could be written as;

$$y_t = A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + Bx_t + \varepsilon_t. \quad (5)$$

Where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t a vector of innovations. We can rewrite this VAR as

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} \ldots\ldots\ldots\ldots. + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t, \quad (6)$$

Where, $\Pi = \left(\sum_{j=1}^{k} \beta_i\right) - I_g$ and $\Gamma_i = \left(\sum_{j=1}^{i} \beta_j\right) - I_g$.

Here, Y_t is an $(n \times 1)$ vector and $\Delta Y_t = Y_t - Y_{t-1}$, and Π and Γ are matrices of coefficients. If the variables are not cointegrated, then the rank of Π will not be significantly different from zero. Particularly, if the rank Π = 0, it implies no cointegration but there will be cointegration if the Π = 1. According to Johansen approach, there are two test statistics for cointegration:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} ln\left(1 - \hat{\lambda}_i\right), \quad (7)$$

$$\lambda_{max}(r, r+1) = -T ln\left(1 - \widehat{\lambda_{r+1}}\right). \quad (8)$$

Where r is the number of cointegrated vectors and $\hat{\lambda}_i$ is the estimated value for the ith order eigenvalue from the Π matrix and T is the total time period. The null hypothesis should be tested for r= 0 and r = 1. The null hypothesis cannot be rejected if r = 0, that means there is no cointegration vector and there is no cointegration. On the other hand, if r = 0 is rejected, we conclude that there is cointegration between the variables. Thus, the value of r is continually increased until the null is no longer rejected.

Causality test

Causality test is different from causality. For instance, the causality from A to B indicates that A causes B directly. Causality is an econometrics tool based on the standard Chi-square-test framework to determine whether one time series is useful to predict the future of another series. For example: variable say X causes Y if the past changes of X could help to predict current changes of Y. If X causes Y and not vice versa, it is called unidirectional causality. If X causes Y and Y also causes X, it would be said that there is bi-directional causality between that variables (Chris Brooks, 2010).

When we conduct causality tests, two cases are considered depending on whether the variables are cointegrated or not.

First, if variables are integrated, the following (Vector Autoregressive) VAR estimation equations in the first differences are tested

$$\Delta Y_t = \sum_{j=1}^{n} b_j \Delta X_{t-j} + \sum_{j=1}^{n} c_j \Delta Y_{t-j} + u_{t-1} \quad (9)$$

$$\Delta X_t = \sum_{j=1}^{n} b_j \Delta Y_{t-j} + \sum_{j=1}^{n} c_j \Delta X_{t-j} + u_{t-1}. \quad (10)$$

Secondly, if the variables are cointegrated, the following vector error correction models (VECM) are tested. The reason to use VECM is that regressing on the first difference cointegrated variables could lead to misspecification error.

It should be noted that causality really represents only a correlation between the current value of one variable and the previous values of others. It doesn't mean that movements of one variable cause movements of another (Chris Brooks, 2010). Moreover, although causality in VAR examines whether the current value of variable X can be explained by the past values of variable Y, it still does not explain the sign of the relationship or how long these effects last.

Vector Error Correction (VEC) Model

The Vector Error Correction Model (VECM) allows the short-run dynamic adjustment of variables to the long-run behavior of the endogenous variables. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Take a simple example of VECM model with two variables as:

$$\Delta y_{1,t} = \alpha_1\left(y_{2,t-1} - \beta y_{1,t-1}\right) + \varepsilon_{1,t}$$

and $$\Delta y_{2,t} = \alpha_2\left(y_{2,t-1} - \beta y_{1,t-1}\right) + \varepsilon_{2,t}. \quad (11)$$

In this model, the right hand side is the error correction term. In long run equilibrium, this term becomes zero. If y_1 and y_2 deviate from the long run equilibrium, this term will be non-zero and each variable adjusts partially to restore equilibrium. The coefficient α_i measures the speed of adjustment of the i^{th} endogenous variable towards the equilibrium.

6. Analysis of estimation results

6.1. Analysis of movements in commodity prices (percentage variation)

International prices of agriculture commodities have been raised in recent years due to tight supply and increase in demand. Table 1 shows the percentage variation in nominal prices of selected commodities indices both for international and domestic markets. It is seen that the domestic agriculture index price has been moved in tandem with the international agriculture index price but at a slower rate, which reflects a less pass-through. These two index prices have fall in the year 2009 but again they rose in 2010 and 2011. The international agriculture index price rose from 7.21% to 50.87 but it's growth rate became negative in 2012. The domestic agriculture index price was continuously rising from 2010 to 2012. The international price of metal had a positive growth rate in 2006 and 2007 but became negative (-13.29% to 25.26%) in the year 2008 and 2009. India's metal price was also moving par with the international metal price. The international energy index price shows a positive growth rate (35.94%) in 2006 but became negative (-5.38) in the year 2007. It had also a positive growth rate (74.46%) in 2008 but it became negative (-37.70%) in 2009. Thereafter, there was positive growth rate in the international energy index price. The domestic energy index price had a positive growth rate in 2006 to 2008 but due to the financial crisis, it had negative growth rate (-43.20%) in 2009 and after that there was positive growth rate.

Table 1. *Growth Rates of Domestic and International Prices of Selected Commodities*

Index/Year	2006	2007	2008	2009	2010	2011	2012
IMF Food Index	23.96	26.14	50.49	-28.94	7.21	50.87	-5.22
India Food Index	-5.02	29.99	40.42	-28.28	14.30	27.35	18.21
IMF Metal Index	52.90	24.73	-13.29	-25.26	23.21	20.86	3.38
India Metal Index	190.04	10.55	-4.95	-23.79	19.96	22.06	2.52
IMF Energy Index	34.87	-15.78	105.04	-40.60	4.12	22.35	11.54
India Energy Index	36.61	-1.37	110.98	-47.33	5.18	17.04	10.10
IMF Com Index	35.94	-5.38	74.46	-37.70	6.75	26.16	7.68
India Com Index	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

Note: Growth rates are percentage changes compared to the previous year.
Source: Author's estimations from IMF and RBI database.

6.2. Analysis of absolute commodity prices

In Tables 2 to 4, we have reported the growth rates of the selected commodities index prices for both domestic and international. Table 2 reports the agriculture commodity index price growth rates for domestic and international. It can be seen that, the domestic agriculture index price is moving on par with the international agriculture index price. The growth rates of the international prices of soybean oil, rapeseed oil, maize and groundnut had positive growth rate from 2006 to 2009. But due to the global financial crisis in 2008, the growth rates became negative in 2009. Palm oil, groundnut, soybean oil, rapeseed oil and maize price had negative growth rates in 2009 and 2010. After that, there have been positive growth rates in 2011 and 2012. Similarly, the domestic growth rates of the agriculture commodities follow the international price but in lower rate.

It is observed that the domestic and international soybean oil prices growth rate have been increased over the periods. In 2006, the soybean oil price growth rate was 9.98% but it increased to 90.39% in 2008 both in the domestic and international markets. Due to the crisis, there was downfall of demand, which led to fall in the growth rate to -34.46% in 2009 and became –3.94% in 2010. There has been a positive growth rate in soybean oil price both in domestic and international markets. Similarly, the growth rate of other edible oil (rapeseed, palm oil and groundnut) price had also the similar trends. These edible oils growth rates increased from 2006 to 2008 and after that, there was negative growth in 2009 both in the domestic and international markets. After that, there were positive growth rates in the edible oils. There were also similar trends in maize and groundnut price growth rates for both domestic and international markets.

In Table 3, we have reported the growth rates of the domestic and international prices of metals. It is seen that both the aluminium and copper have the similar growth trends both for domestic and international markets. There have been increased the aluminium and copper price in 2006 to 2008 and declined in the year 2009. After that there have upward trends in the growth rates in both domestic and international markets. Except the year 2007, the gold price has positive growth rate in the selected years. Except 2009, in all other years silver price has positive growth rate. The other metals like lead, nickel and zinc have the similar growth trends. At first, there is increased growth rates but it declined in the year 2008 and 2009 and then there have been positive growth rates.

In Table 4, we have reported the growth rates of the domestic and international prices of energy commodities. It has been seen that in 2006, there was a positive growth rate of energy in both domestic and international markets but it became negative in 2007. In 2008 there had a positive growth rate but became negative in 2009. Thereafter, it had positive growth rates in both domestic and international markets. In a similar manner, the natural gas had the similar trend like crude oil in both domestic and international markets. Except the year 2007 and 2009, there had positive growth rates in both domestic and international markets.

Table 2. *Growth of Domestic and International Prices of Selected Agriculture Commodities (in %)*

Commodity/Year		2006	2007	2008	2009	2010	2011	2012
Soybean Oil	International	9.98	25.86	90.39	-34.46	-3.94	46.17	10.57
	India	8.49	22.92	43.20	-32.99	-6.30	44.79	18.46
Rapeseed Oil	International	32.10	1.92	61.83	-30.89	-8.98	58.84	-8.98
	India	1.94	25.46	48.60	-32.83	2.27	27.70	29.29
Maize	International	13.25	50.52	55.65	-22.49	-19.14	101.25	-6.98
	India	11.91	24.27	23.62	-5.88	11.32	21.74	3.05
Palm oil	International	5.37	94.27	30.64	-21.59	4.74	39.38	-6.82
	India	-46.98	64.52	78.10	-34.40	8.61	31.48	18.14
Rubber	International	88.50	-16.72	27.48	-36.12	102.70	37.12	-29.94
	India	76.07	-30.16	75.80	-24.03	81.26	16.19	-10.93
Groundnut	International	11.32	36.76	34.35	-27.77	17.45	48.04	7.47
	India	-2.62	60.12	-7.90	-18.83	32.90	18.18	34.62

Note: Growth rates are percentage changes from the previous year.
Source: Author's calculations from IMF and RBI database.

Table 3. *Growth of Domestic and International Prices of Selected Metal Commodities (in %)*

Commodity/Year		2006	2007	2008	2009	2010	2011	2012
Aluminium	International	52.32	-4.81	16.65	-40.41	18.35	27.26	-7.19
	India	NA	-6.85	20.65	-41.42	15.90	25.15	-7.93
copper	International	116.71	-8.00	16.29	-32.60	26.19	33.88	3.15
	India	123.92	-9.94	18.10	-32.93	21.67	45.84	-0.64
Gold	International	46.60	-2.74	42.97	18.52	26.86	19.08	31.61
	India	43.75	-4.12	50.42	12.54	29.17	16.68	34.87
Lead	International	3.85	123.62	-19.53	-0.05	-0.41	41.98	-7.71
	India	NA	145.11	-30.88	11.07	-4.89	48.89	-13.77
Nickel	International	35.30	78.50	-42.78	-26.08	26.24	10.88	-6.77
	India	60.55	42.39	-36.27	-17.70	18.15	14.17	-10.26
Silver	International	56.41	7.67	36.05	-3.73	22.54	86.20	-1.57
	India	52.40	6.25	44.15	-8.64	31.54	75.64	0.43
Zinc	International	166.00	0.36	-44.64	-9.03	9.26	22.82	4.57
	India	NA	-10.45	-40.22	-7.34	9.40	26.56	0.58

Note and Source: Same as in Table 1.

Table 4. *Growth of Domestic and International Prices of Selected Energy Commodities (in %)*

Commodity/Year		2006	2007	2008	2009	2010	2011	2012
Crude Oil	International	33.21	-15.85	109.13	-42.08	5.37	22.62	7.73
	India	36.61	-15.47	112.05	-44.28	4.58	19.67	12.33
Natural Gas	International	56.46	-14.93	60.16	-19.44	-8.80	19.10	58.13
	India	NA	NA	104.60	-66.34	11.31	-8.36	-18.00

Note and Source: Same as in Table 1.

6.3. Correlations between domestic (Indian) and international commodity prices

To examine further the extent of relationship between international and domestic prices, the correlation coefficient analysis is carried out. The correlation coefficient between domestic and international prices both in index prices and absolute prices are reported in Table 5. It shows that during the study period 2001 to 2012, all three index prices between international and domestic prices were positive and highly correlated. It means both international and domestic prices are moving together. If we look at the correlation between the absolute prices of commodities, it can be seen that there have positive correlations between all commodities except the natural gas price. It means both international and domestic prices for the selected study variables except the natural gas prices are moving positively.

Table 5. *Correlations between Domestic (India) and International Prices*

Food Index	Metal Index	Energy Index	All Commodity Index		
0.96	0.96	0.95	0.97		
Food	Correlation	Metal	Correlation	Energy	Correlation
Groundnut	0.89	Aluminium	0.97	Crude Oil	0.98
Maize	0.89	Copper	0.97	Natural Gas	-0.08
Palm Oil	0.95	Gold	0.996		
Rapeseed Oil	0.82	Lead	0.97		
Rubber	0.95	Nickel	0.98		
Soya Oil	0.95	Silver	0.99		
		Zinc	0.98		

Source: Author's calculation.

6.4. Volatility in domestic (Indian) and international commodity prices

The commodities price volatilities are measured by the coefficient of variation (C.V.) and is reported in Table 6. It is observed that the domestic agriculture index price is less volatile than the international agriculture index price. But the domestic metal and energy index prices are more volatile than the international metal and energy index prices. The domestic all commodity price indices are more volatile than the international.

The C.V. of the individual commodities shows that the international agriculture and agriculture items, (i.e. soybean oil, palm oil, maize, groundnut, rapeseed oil and rubber prices) are more volatile than the domestic prices. But the domestic metals like; copper, nickel and silver prices are more volatile than their international prices. The international prices of aluminium, gold, lead and zinc are more volatile than the domestic prices. In energy, international crude oil price is more volatile than the domestic price, but the domestic natural gas price is more volatile than the international price.

Table 6. *Coefficient of Variation of Prices of Selected Commodities*

Index		Mean	S.D.	CV
Food Index	International	109.85	33.31	30.33
	India	111.41	28.64	25.71
Metal Index	International	129.21	26.12	20.22
	India	123.57	30.66	24.81
Energy	International	107.73	26.85	24.93
	India	106.56	26.82	25.17
All Commodity Index	International	110.49	25.69	23.25
	India	109.19	25.48	23.33
Food				
Groundnut	International	563.48	174.74	31.01
	India	696.87	190.35	27.31
Maize	International	858.51	300.21	34.97
	India	865.05	211.55	24.46
Palm Oil	International	338.95	123.07	36.31
	India	359.39	128.61	35.79
Rapeseed Oil	International	479.57	113.54	23.67
	India	537.46	119.66	22.26
Rubber	International	1292.21	539.00	41.71
	India	1283.93	527.82	41.11
Soya Oil	International	405.92	129.35	31.87
	India	516.63	111.86	21.65
Metal		Mean	S.D.	CV
Aluminium	International	10356.16	1573.61	15.19
	India	10512.19	1559.22	14.83
Copper	International	31313.56	8082.69	25.81
	India	31486.69	8184.96	25.99
Gold	International	14807.87	6595.55	44.54
	India	15090.20	6687.73	44.32
Lead	International	8817.37	2649.06	30.04
	India	9437.40	2341.59	24.81
Nickel	International	10090.12	3457.48	34.27
	India	10117.75	3532.42	34.91
Silver	International	27253.69	14558.69	53.42
	India	28578.72	15363.59	53.76
Zinc	International	10358.93	3191.06	30.80
	India	10742.73	3251.52	30.27
Energy				
Crude Oil	International	3594.35	931.13	25.91
	India	3628.60	922.54	25.42
Natural Gas	International	3960.94	1278.02	32.27
	India	2477.77	911.54	36.79

Source: Author's calculations from IMF and RBI database.

6.5. Analysis of market integration and price transmission

The Tables 7A and 7B report the Unit root test of ADF and PP tests. In both Tables (7A and 7B), we have reported the level and first difference values for intercept and intercept with trend for three periods, full-sample period (2001M01 to 2012M06), pre-crisis period (2001M01 to 2008M09) and post-crisis period (2008M10 to 2012M06). It is seen that all variables are non-stationary at their level values both in intercept and intercept with trend in all three periods but all variables are significant in the first difference for these three periods. Hence, all variables are I(1).

Table 7A. *Augmented Dickey Fuller Unit Root Test Results*

	Full-Sample				Pre-Crisis				Post-Crisis			
	Int		Int with Trend		Int		Int with Trend		Int		Int with Trend	
Variable	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff
IAC	0.81	-9.72*	-2.77	-9.76*	1.26	-7.80*	-2.73	-7.91*	0.16	-6.23*	-3.39	-6.11*
IFOOD	0.14	-11.84*	-2.28	-11.84*	-0.11	-8.13*	-2.11	-8.07*	-1.47	-6.72*	-2.21	-6.69*
IENERGY	-0.18	-8.35*	-2.77	-8.34*	0.69	-8.37*	-2.04	-8.48*	0.61	-5.39*	-3.41	-4.94*
IMETAL	0.35	-4.09*	-2.02	-4.26*	-0.37	-3.33*	-2.08	-4.32*	-0.01	-3.99*	-2.33	-4.16*
WAC	-1.01	-7.84*	-3.36	-7.80*	0.28	-6.68*	-2.92	-6.78*	-0.61	-5.82*	-2.91	-5.61*
WFOOD	-0.95	-7.90*	-3.03	-7.86*	-0.03	-5.65*	-2.34	-5.70*	-0.68	-5.34*	-1.89	-5.23*
WENERGY	-1.35	-8.40*	-3.41	-8.36*	0.43	-7.52*	-3.18	-7.59*	-1.09	-5.66*	-3.48	-5.45*
WMETAL	0.36	-11.72*	-2.97	-11.73*	0.10	-9.75*	-2.46	-9.74*	-0.47	-7.39*	-3.09	-7.29*

Notes: a. Critical values for unit root test (ADF & PP) are: -3.49 and -4.10 (without trend) and-4.04, -4.10 (with trend) respectively at 1% level and 5% levels.
b. * and ** denote significant at 1 percent and 5 percent, respectively.
Source: Author's calculation.

Table 7B. *Phillips Perron Unit Root Test Results*

	Full-Sample				Pre-Crisis				Post-Crisis			
	Int		Int with Trend		Int		Int with Trend		Int		Int with Trend	
Variable	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff	Level	First Diff
IAC	0.63	-9.70*	-2.31	-9.73*	1.12	-7.78*	-2.41	-7.85*	0.10	-6.70*	-3.36	-6.47*
IFOOD	0.64	-12.50*	-2.09	-12.81*	0.59	-8.17*	-1.90	-8.07*	-1.36	-7.15*	-2.27	-7.46*
IENERGY	-0.19	-8.36*	-2.52	-8.35*	0.65	-8.34*	-2.16	-8.42*	0.01	-6.27*	-3.13	-5.46*
IMETAL	0.73	-6.33*	-1.66	-6.57*	-0.01	-6.34*	-1.89	-6.40*	0.38	-3.90*	-2.11	-4.10*
WAC	-0.81	-7.77*	-3.41	-7.74*	0.73	-6.63*	-2.46	-6.70*	-0.76	-5.82*	-3.24	-5.61*
WFOOD	-0.70	-7.83*	-3.29	-7.79*	0.55	-5.52*	-1.81	-5.57*	-0.86	-5.34*	-2.32	-5.22*
WENERGY	-1.19	-8.44*	-3.17	-8.41*	0.28	-7.38*	-2.70	-7.41*	-1.34	-5.78*	-2.73	-5.51*
WMETAL	0.37	-11.72*	-3.13	-11.73*	0.12	-9.74*	-2.59	-9.74*	-0.15	-8.77*	-3.09	-8.90*

Notes and Source: Same as in Table 7A.

6.6. Analysis of cointegration test results

The long-run cointegration relationship between the domestic and international commodities index prices are measured by using the Johansen cointegration test, are reported in Tables 8A to 8C. Table 8A reports the cointegration results for the full-sample period (January 2001 to June 2012). The Table 8A shows that there is a long run equilibrium relationship between domestic all commodity index price (DACP) and international all commodity index price (DACPP) in the full-sample period (January 2001 to June 2012). But there is no long-run relationship between domestic agriculture index price (DAP) and international agriculture index price (IAP). There is log-run equilibrium relationship between domestic energy index price (DEP) and international energy index price (IEP). There is also long-run relationship between domestic metal index price (DMP) and international metal index price (IMP) in the full-sample period.

Table 8B reports the cointegration results for the pre-crisis period (January 2001 to September 2008). It indicates that there is long run cointegration between DACP and IACP in the pre-crisis period. There is no long-run relationship between DAP and the

IAP. There is also a long-run relationship between DEP and the IEP, and also between DMP and IMP. Table 8C reports the cointegration results for the post-crisis period. It indicates that there is no long run relationship between DACP and IACP in the post-crisis period. There is also no cointegration between (DAP) and IAP. But there is a long-run equilibrium relation between DEP price and IEP price. There is no long-run relationship between DMP price and IMP price during this period.

Table 8A. *Results of Johansen Cointegration Test for Full-Sample*

Variables		Null hypothesis		Eigen		Critical Values	
				Value	Stat	5%	Prob.
WAC	IAC	λ_{trace} tests	r = 0	0.117	24.983	20.262	0.010
			r ≤ 1	0.058	8.087	9.165	0.080
		λ_{max} test	r = 0	0.117	16.896	15.892	0.035
			r = 1	0.058	8.087	9.165	0.080
WAGRI	IAGRI	λ_{trace} tests	r = 0	0.080	11.223	15.495	0.198
			r ≤ 1	0.002	0.205	3.841	0.651
		λ_{max} test	r = 0	0.080	11.018	14.265	0.153
			r = 1	0.002	0.205	3.841	0.651
WENERGY	IEnergy	λ_{trace} tests	r = 0	0.113	25.533	20.262	0.009
			r ≤ 1	0.067	9.321	9.165	0.047
		λ_{max} test	r = 0	0.113	16.212	15.892	0.045
			r = 1	0.067	9.321	9.165	0.047
WMETAL	IMetal	λ_{trace} tests	r = 0	0.117	24.983	20.262	0.010
			r ≤ 1	0.058	8.087	9.165	0.080
		λ_{max} test	r = 0	0.117	16.896	15.892	0.035
			r = 1	0.058	8.087	9.165	0.080

Note: r denotes the cointegration vector.
Source: Author's estimations from IMF and RBI database.

Table 8B. *Results of Johansen Cointegration Test for Pre-Crisis*

Variables		Null hypothesis		Eigen		Critical Values	
				Value	Statistics	5%	Prob.
WAC	IAC	λ_{trace} tests	r = 0	0.393	30.740	20.262	0.001
			r ≤ 1	0.207	9.759	9.165	0.039
		λ_{max} test	r = 0	0.393	20.980	15.892	0.007
			r = 1	0.207	9.759	9.165	0.039
WAGRI	IAGRI	λ_{trace} tests	r = 0	0.242	25.502	15.495	0.001
			r ≤ 1	0.003	0.288	3.841	0.591
		λ_{max} test	r = 0	0.242	25.214	14.265	0.001
			r = 1	0.003	0.288	3.841	0.591
WENERGY	IEnergy	λ_{trace} tests	r = 0	0.501	47.578	25.872	0.000
			r ≤ 1	0.337	17.652	12.518	0.006
		λ_{max} test	r = 0	0.501	29.926	19.387	0.001
			r = 1	0.337	17.652	12.518	0.006
WMETAL	IMetal	λ_{trace} tests	r = 0	0.123	23.200	20.262	0.019
			r ≤ 1	0.039	5.363	9.165	0.246
		λ_{max} test	r = 0	0.123	17.837	15.892	0.025
			r = 1	0.039	5.363	9.165	0.246

Source and Note: Same as in Table 8A.

Table 8C. *Results of Johansen Cointegration Test for Post-Crisis*

Variables		Null hypothesis		Eigen Value	Stat	Critical Values 5%	Prob.
WAC	IAC	λ_{trace} tests	r = 0	0.166	8.410	15.495	0.423
			r ≤ 1	0.014	0.610	3.841	0.435
		λ_{max} test	r = 0	0.166	7.800	14.265	0.399
			r = 1	0.014	0.610	3.841	0.435
WAGRI	IAGRI	λ_{trace} tests	r = 0	0.231	12.968	15.495	0.116
			r ≤ 1	0.038	1.677	3.841	0.195
		λ_{max} test	r = 0	0.231	11.291	14.265	0.140
			r = 1	0.038	1.677	3.841	0.195
WENERGY	IEnergy	λ_{trace} tests	r = 0	0.406	27.329	20.262	0.005
			r ≤ 1	0.108	4.928	9.165	0.291
		λ_{max} test	r = 0	0.406	22.401	15.892	0.004
			r = 1	0.108	4.928	9.165	0.291
WMETAL	IMetal	λ_{trace} tests	r = 0	0.236	11.525	15.495	0.181
			r ≤ 1	0.006	0.240	3.841	0.624
		λ_{max} test	r = 0	0.236	11.285	14.265	0.141
			r = 1	0.006	0.240	3.841	0.624

Source and Note: Same as in Table 8A.

6.7. Analysis of VECM results

From the above Johansen cointegration test, it is found that there is long-term relationship between the Indian commodity prices and the international commodity prices. To support/verify that finding, now it is necessary to test whether there is any short-run relationship. Hence, to examine the short-run relationship between Indian commodity prices and the international prices, we have used the Vector Error correction model (VECM). The estimation of VECM requires the appropriate lag selection. Therefore, we have used the SIC and AIC lag selection criteria to choose the optimum lag. The estimated VECM results are reported in Table 9 (block I to III) for the three periods.

Table 9 (block I) reports the VECM results for the full period. It indicates that The VECM result for the DACP and IACP coefficients (-0.05) is statistically significant at 5% significance level. This means, there is short-run relationship between DACP and IACP. The DAP and IAP VECM coefficient is not significant. Therefore, there is no short-run dynamic relationship between DAP prices and IAP prices. There is a short-run dynamic relationship between DEP with and IEP price. There is also short-run dynamic relationship between DMP and IMP for the full-sample period, i.e., from January 2001 to June 2012.

In Table 9 (block II), indicates the VECM results for the pre-crisis period. It shows that there is short-run relationship between DACP and IACP. There is no short-run relationship between DAP prices with IAP prices. There is a short-run dynamic relationship between DEP and the IEP. There is no short-run dynamic relationship between DMP and IMP.

Table 9 (block III) reports the VECM results for the post-crisis sample period. The VECM result for the DACP and IACP indicates that there is no short-run dynamic relationship between DACP and IACP. There is also no short-run relationship between

DAP prices and IAP prices. There is a short-run dynamic relationship between DEP and the IEP. There is no short-run dynamic relationship between DMP with IMP.

Table 9. *Results of the Vector Error Correction Model*

I. Full-Sample				
Variable		ECM Coeff	t-stat	Lag
WAC	IAC	-0.05	-3.88	1.00
WFOOD	IFOOD	-0.04	-1.36	2.00
WENERGY	IENERGY	-0.05	-2.68	2.00
WMETAL	IMETAL	-0.03	-2.89	1.00
II. Pre-Crisis				
WAC	IAC	-0.11	-4.26	1.00
WFOOD	IFOOD	-0.12	-4.51	1.00
WENERGY	IENERGY	-0.23	-3.30	1.00
WMETAL	IMETAL	-0.05	-4.15	1.00
III. Post-Crisis				
WAC	IAC	-0.09	-1.36	1.00
WFOOD	IFOOD	-0.09	-0.95	1.00
WENERGY	IENERGY	-0.08	-5.25	2.00
WMETAL	IMETAL	-0.05	-1.67	2.00

Source: Author's estimations.

6.8. Analysis of causality test

From the above cointegration test and VEC model, we have found that the commodity prices (except the agriculture price) of India and international are co-integrated both in the long-run as well as in the short-run. This suggests that except the agriculture prices, all other commodity prices between India and international are integrated. But to know which is the cause and who is the effect, we have reported the VECM lag coefficients. This suggests the direction of causality between the variables. Results are reported in Tables 10 to 13.

In Table 10, the estimated results show that there is causality from the IACP price to DACP price in the full-sample period. In the pre-crisis period, there is also causality from IACP price to the DACP price. But in the post-crisis period, there is no causality between IACP and DACP index prices. Table 11 indicates that in the full-sample period, there is no causality between IAP price and DAP price. In the same manner, in other two periods, i.e., pre-crisis and post-crisis, there is no causal relationship between IAP and DAP index prices.

Results in Table 12 indicate that in the full-sample period, the change in DEP price is caused by the IEP price. In the pre-crisis period, the change in IEP price causes the change in DEP price but not vice versa. Similarly, in the post-crisis period, it is also seen that the change in DEP price is due to change in the IEP price. Table 13 reports that in the full-sample period, the change in DMP price is not caused by the change in IMP price but by its own lag price. Similarly, in the pre-crisis period, the change in DMP price is not caused by the IMP prices and in the post-crisis period, the change in DMP price is also not caused by the change in IMP price but by its own lag price.

Table 10. *Causality between IAC with WAC*

		Full-Sample		Pre-Crisis		2008M10 to 2012M06	
		D(Log(IAC))	D(Log(WAC))	D(Log(IAC))	D(Log(WAC))	D(Log(IAC))	D(Log(WAC))
D(Log(IAC(-1)))		0.087	0.463	-0.022	-0.456	0.093	0.370
	t-stat	1.113	1.428	-0.241	-0.933	0.628	0.857
D(Log(WAC(-1)))		0.089	0.380	0.071	0.398	0.035	0.267
	t-stat	4.270	4.382	3.323	3.433	0.697	1.824

Source: Author's estimations.

Table 11. *Causality between IAGRI with WAGRI*

		Full-Sample		Pre-Crisis		Post-Crisis	
		D(Log(IAGRI))	D(Log(WAGRI))	D(Log(IAGRI))	D(Log(WAGRI))	D(Log(IAGRI))	D(Log(WAGRI))
D(Log(IAGRI(-1)))		0.004	0.008	0.140	-0.097	0.012	-0.260
	t-stat	0.047	0.048	1.524	-0.233	0.065	-1.081
D(Log(IAGRI(-2)))		-0.030	-0.205				
	t-stat	-0.344	-1.184				
D(Log(WAGRI(-1)))		-0.019	0.331	-0.030	0.548	-0.053	0.150
	t-stat	-0.446	3.924	-1.411	5.582	-0.521	1.087
D(Log(WAGRI(-2)))		-0.025	0.184				
	t-stat	-0.557	2.139				

Source: Author's estimations.

Table 12. *Causality between IENERGY with WENERGY*

		Full-Sample		Pre-Crisis		Post-Crisis	
		D(Log (IENERGY))	D(Log (WENERGY))	D(Log (IENERGY))	D(Log (WENERGY))	D(Log (IENERGY))	D(Log (WENERGY))
D(Log(IENERGY(-1)))		0.041	0.506	-0.020	-0.217	-0.087	0.717
	t-stat	0.478	1.166	-0.243	-0.528	-0.691	0.837
D(Log(IENERGY(-2)))		-0.047	-0.047			-0.025	-0.557
	t-stat	-0.646	-0.128			-0.241	-0.784
D(Log(WENERGY(-1)))		0.123	0.334	0.112	0.341	0.017	-0.102
	t-stat	6.758	3.622	4.578	2.836	0.743	-0.662
D(Log(WENERGY(-2)))		0.043	0.088			0.041	0.129
	t-stat	2.014	0.812			2.191	0.850

Source: Author's estimations.

Table 13. *Causality between IMETAL with WMETAL*

		Full-Sample		Pre-Crisis		Post-Crisis	
		D(Log (IMETAL))	D(Log (WMETAL))	D(Log (IMETAL))	D(Log (WMETAL))	D(Log (IMETAL))	D(Log (WMETAL))
D(Log(IMETAL(-1)))		0.556	-0.156	0.189	-0.700	0.582	0.285
	t-stat	7.811	-0.484	1.906	-1.213	3.378	0.536
D(Log(IMETAL(-2)))				0.374	0.325	0.032	-0.156
	t-stat			3.807	0.567	0.190	-0.303
D(Log(WMETAL(-1)))		-0.025	-0.007	-0.005	-0.013	-0.054	-0.160
	t-stat	-1.257	-0.077	-0.262	-0.109	-1.067	-1.027
D(Log(WMETAL(-2)))				-0.011	-0.063	0.009	-0.214
	t-stat			-0.537	-0.518	0.181	-1.456

Source: Author's estimations.

7. Conclusions

This study examines the market integration and price transmission between domestic and international commodity prices. The study finds that there is both short-run and long-run relationship between DACP and IACP in full-sample and pre-crisis period. But in the post-crisis period, there is no long-run relationship between DACP and IACP index price.

In all periods, there is no relationship between DAP and IAP. It finds that there is both log-run and short-run equilibrium relationship between DEP price and IEP price in the three sample periods. In the full-sample and pre-crisis periods, there is both log-run and short-run equilibrium relationship between DMP and IMP index prices but not in the post-crisis period.

The study also finds that the change in DACP prices is due to the change in IACP prices in full-sample period. In the post-crisis period there is no causal relationship between IACP on DACP. In the case of agriculture and agriculture prices, the change in DAP prices is not due to the IAP prices in all the three sample periods. In the energy price, the change in DEP price is due to change in IEP price in all the three periods. In the case of metal prices, in the full-sample and pre-crisis period, the change in DMP price is due to the change in IMP price but in the post-crisis period, there is no effect of IMP price on DMP index price.

Thus, the main finding of the paper is similar to other studies like Jha et al. (2005), Ghosh (2012), and Rajmal and Mishra (2009). These studies found that the domestic commodity prices co-moved with global commodity prices. But the integration of agricultural commodities was far from the complete in India and a major reason for this was the excessive government interventions.

Notes

(1) This is mainly drawn from Acharya et al. (2012), Ghafoor and Aslami (2012) and Jha et al. (2005).

(2) This section draws on Rajmal and Mishra (2009), McNew (1996), Sanogo (2008) and Goodwin (2006).

(3) The econometric model exaltations are drawn from the Brooks (2008) and Tsay (2010).

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Appendix

1. Construction of commodity price index

In this section, we have reported the construction of an India-specific commodity price index to assess the impact of fundamental factors on commodity prices in India. While constructing the index, we have captured the relative importance of the commodity for India using the weight of the commodity in the WPI basket (base 2004-2005). In Appendix, Table A1 reports the commodity price weight in WPI (2004-2005). Though, it is necessary that the aggregate weights of commodities should be equal to 100, we have reweighted to each commodity by distributing 100 and the new (i.e., re-weights) weights of commodities are used to construct the commodity index using the spot prices of 14 commodities. We have normalized the component prices to a common scale, so that the weights are not distorted by the difference in values of different components. For this purpose, we have constructed the commodity index by anchored 100 for January 2009. The values for all other periods are divided by the average value for January 2009 to obtain the component value before combining the individual components into a combined index. The formation of commodity price index is followed by the Laspeyres price index. The Laspeyres price index formula is:

$$L_t = \frac{\sum_{j=1}^{n} p_{jt} q_{j0}}{\sum_{j=1}^{n} p_{jo} q_{j0}} \times 100.$$

where, the subscript "j_0" refers to the base month value for good j, and, t refers to the current month. By using this formula, we have estimated four commodity indices – agricultural commodity index, metal index, energy index and all commodity index.

Table A1. *WPI Weights for the Base Year 2004-05*

Commodity	WPI Weight	New Weight	Commodity Index	Weight
Cereals	3.37	11.94		
Sugar, khandari and gur	2.09	7.40		
Edible oils	3.04	10.78		
Cotton Textile	2.61	9.22		
Rubber & Plastic Products	2.99	10.58	Food Index	49.9
Mineral oils	9.36	33.16		
Coal	2.09	7.42	Energy Index	40.6
Aluminium	0.49	1.73		
Other non-ferrous metal	0.52	1.82		
Metal Products	1.68	5.95	Metal Index	9.5

Source: Author's calculations.

2. Gregory-Hansen structural break model

The Gregory-Hansen cointegration test (see Gregory and Hansen, 1996a and 1996b) is used in the time series data to find out the break points. This test gives three types of breaks – (i) it shows the break in intercept only, (ii) it shows break in trends only, and (iii) it gives the break in intercept with trend. In Table A2, we have reported the results of Gregory-Hansen test for India. It is seen that commodity price indices have structural breaks in trends only, and the intercept with trend. In this study, we considered the structural break in intercept with trend.

Table A2. *Gregory-Hansen Cointegration Test for Structural Breaks for the Period 2001 to 2012*

I. All Commodity Index				
	Brake Date	GHTest	5% Critical	Reject null hypothesis of
		Statististics	Value	no Cointegration
GH-I	2010-10	4.832	5.280	No
GH-II	2010-06	5.580	5.570	Yes
GH-III	2008-10	6.109	6.000	Yes
II. Food Index				
	Brake Date	GHTest	5% Critical	Reject null hypothesis of
		Statististics	Value	no Cointegration
GH-I	2010-01	5.333	5.280	No
GH-II	2010-06	5.756	5.570	Yes
GH-III	2008-10	6.140	6.000	Yes
III. Energy Index				
	Brake Date	GHTest	5% Critical	Reject null hypothesis of
		Statististics	Value	no Cointegration
GH-I	2010-10	4.142	5.280	No
GH-II	2008-10	5.601	5.570	Yes
GH-III	2008-11	6.665	6.000	Yes
IV. Metal Index				
	Brake Date	GHTest	5% Critical	Reject null hypothesis of
		Statististics	Value	no Cointegration
GH-I	2008-09	3.654	5.280	No
GH-II	2010-04	5.684	5.570	Yes
GH-III	2008-10	6.098	6.000	Yes

Note: GH-I is break in intercept, GH-II is break in trend and GH-II is break in intercept & trend.
Source: Author's estimations from RBI database.