Price Discovery and Volatility Spillover: Evidence from Indian Commodity Markets

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ABSTRACT

This paper examines the price discovery and volatility spill-over relationship for Indian commodity markets. We cover twelve actively traded commodities including agriculture, metal and energy and four commodity indices. Price discovery is confirmed for eight commodities and three indices with a greater role for futures markets in the price discovery process. Price discovery results are encouraging given the nascent character of commodity markets in India. However the market does not seem to be competitive. Volatility spill-over is confirmed for only three commodities and none of the indices. This implies the Indian Commodity Market is yet to evolve an efficient risk transfer system for most commodities. The findings have implications for policy makers, hedgers and investors. The research contributes to alternative investment literature for emerging markets such as India.

JEL: G13; G14; G 15; G18; C32

KEYWORDS: Price discovery, Granger Causality, VECM, EGARCH, Volatility, Spillover

INTRODUCTION

Commodities are regarded as separate assets in the realm of all assets classes. Commodity markets are volatile. This price volatility impels the demand for hedging the risk in the commodity market by producers and consumers. In response to this need, derivative markets for commodity risks trading arose. Their use has become extensive. There are many instruments traded in these markets including financial instruments such as futures and forward contracts, options, swaps, and physical instruments like inventories. Future contracts are among the most important of these instruments, and provide significant information about cash and storage markets. Price discovery, hedging, financing, liquidity, price stabilization, encouraging competition, increasing efficiency, inherent leverage, low transaction costs, and lack of short sale restrictions as well as fulfilling desires of speculators are some of the prime economic functions of the futures market.

Price discovery and risk transfer are two major contributions of futures market towards the organization of economic activity (Garbade and Silber, 1983). Price discovery refers to the use of future prices for pricing cash market transactions. This implies that future prices represent a market's expectations of the subsequent spot price. Understanding the influence of one market on the other and the role of each market segment in price discovery is the central question in market microstructure design and is very important to academia and regulators. In efficient markets, new information is impounded simultaneously into cash and futures markets (Zhong et al. 2004). In other words, financial market pricing theory states that market efficiency is a function of how fast and how much information is reflected in prices. The rate at which prices exhibit market information is the rate at which this information is disseminated to market participants (Zapata et al. 2005). In reality, institutional factors such as liquidity, transaction costs, and other market restrictions may produce an empirical lead-lag relationship between price changes in the two markets. Moreover, all markets do not trade simultaneously for many assets and commodities. Besides being of academic interest, understanding information flow across markets is important for hedge funds, portfolio managers and hedgers for hedging and devising cross-market investment strategies. The market that provides the greater liquidity and low trading cost as advocated by Fleming, Ostdiek and Whaley (1996) is likely to play a more important role in price discovery.

Volatility is another area of interest for regulators and market participants who prefer less volatility to more volatility. A meaningful interpretation of volatility gives significant information and acts as a measure of how far the current prices of an asset deviates from its average past prices. At a fundamental level, volatility specifies the strength or the confidence behind a price move. Instinctively, it can be argued that measurement issues of volatility can also be useful to comprehend market assimilation, co-movement and spillover effect. The existence of volatility spillover between two markets specifies that the volatility of returns in one market has an important effect on the volatility of returns in the other market. Kavussanos and Visvikis (2004) note, market agents can use the volatility transmitting market in order to cover the risk exposure they challenge. A considerable amount of research has been conducted in the field of volatility and its spillover, the results of which are mixed. For modeling volatility the work done by Pre-eminence of Bollerslev (1986), Engle (1982), Bollerslev and Engle and (1986) is noteworthy. Therefore, it is necessary, from time to time, to conduct empirical studies to measure the impact of financial derivatives, in our case commodity futures, on volatility spillover to spot market and vice-versa.

Commodity futures' trading has existed in India since 1875. However, commodity futures have been in a state of hibernation for the past few decades owing to government restrictions. Significant developments took place in 2003-04 related to commodity futures markets in terms of revoking prohibition on non-transferable specific delivery forward contracts. The futures market was opened in anticipation of sound institutional framework and market design. At present there are five national and sixteen regional commodity exchanges operating in India. The total volume of trade in the commodity future market rose from Rs.20.53 trillion in 2005-06 to Rs.112.52 trillion in 2010-11. A number of committees have been constituted to inspect, control, and standardize this market at numerous occasions at the behest of government of India, namely, A.D. Shroff Committee (1950), M. L. Dantwala Committee (1966), A.M. Khusro Committee (1979), K.N. Kabra Committee (1993), Shankarlal Guru Committee (2001), Habibullah Committee (2003), and lastly Sen Committee (2008). These committees "recommendations, inevitably provide indications with respect to measuring the efficiency of Indian commodity futures markets, contentions at the back of low extent of participation or on the contrary, unwarranted speculation, and inference behind impositions of ban on several commodities telling to their economic fundamentals and trade-policies (FTGKMC, 2011).

Issues like price discovery and volatility spillover have been extensively researched for mature markets with greater focus on equity markets. The work is limited for commodity markets in emerging markets in general and India in particular. In this backdrop, we revisit the debate on price discovery and volatility spillover in Indian commodities market. The present study covers empirical analysis for commodity indices as well as a large number of individual commodities. It covers a fairly longer study period compared to prior research of the subject and also analyzes how price discovery and volatility spillover relationships vary across commodity classes i.e. agriculture, metal and energy baskets. The study attempts to address the following questions: 1. If futures prices are useful in price discovery mechanism of spot prices? 2.) Is there a volatility spillover from futures market to spot market and vice-versa? 3.) Whether price discovery and volatility spillover relationship differ for commodity indices and individual commodities? and 4.) Do these relationships differ across different commodity classes?

The remainder of the paper is organized as follows. Section one gives review of literature and the relevance of study. Section two contains description of data and the methodology employed along with the empirical tests carried out. Section III exhibits analysis and interpretation of the data through a variety of tables into which relevant details have been compressed and summarized under appropriate heads and presented in the tables. Section IV provides brief summary, conclusion of the main findings, policy implications, limitations of the study and directions for future research.

LITERATURE REVIEW

Numerous studies have explored the ascertainment of whether the price information is reflected in the spot market or in its underlying futures market under various interval of time since the introduction of futures in Indian commodity market. Derivatives trading in the commodity market have been a topic of enthusiasm of research in the field of finance. There have been contrary views on the impact of derivatives trading. A number of studies study the impact of introduction of future trading in commodity markets on the price volatility. There have been two sets of findings, one stating the introduction of derivatives in the stock market has increased the volatility and market performance. The other stating the introduction of derivatives has reduced the volatility in stock market thereby increasing stability. This study adds to the existing literature in this field using some econometric tools like Co-integration, VECM models and Block Exogeneity Test (Causality Test) to bring conclusiveness to the subject.

Garbage and Silber (1983) use simultaneous price dynamics to model spot and future prices, in which changes in spot and futures prices on t are a function of the basis on t-1, this model has been extended on four storable agricultural commodities to examine the characteristics of spot and future characteristics. They suggested that price discovery role of future market might be affected by liquidity and market size. Edwards (1988a & 1988b) studied spot price volatility before and after the introduction of futures and find that futures may induce price volatility in the short run but this volatility did not appear in the long run. Koontz *et al.* (1990) investigate the spatial price discovery mechanism in the livestock market and found that there was high degree of interaction between cash and futures prices using Geweke's causality test (1982). They also find that the price discovery process is dynamic and the structure of the market influences it. Thomas and Karande (2001) analyze price discovery in India's castor seed market and show that markets that trade exactly the same asset in the same time zone, do react differently to information and also a small market may lead a large market. Moosa (2002) with the objective to find out if crude oil performs the function of price discovery and risk transfer re-examine the Garbade and Silber (1983) model. With the daily data he finds that sixty percent of the price discovery function is performed by the futures. It is also discovered in the results that there is a fairly elastic supply of arbitrage system and that Garbade and Silber model is more suitable for intraday behaviour of spot and future prices.

Kumar and Sunil (2004) examine the price discovery for five commoditiies in six Indian commodities exchanges. Daily futures and comparable ready prices have been used in the study and the ratio of standard deviations of spot and future rates have been taken for empirical testing of ability of futures markets to incorporate information well. Besides, the study empirically analyzes the efficiency of spot and future markets by employing the Johansen cointegration technique. They find the inability of the futures market to fully incorporate information and confirmed inefficiency of the future market. The authors conclude Indian agricultural commodities future markets are not yet mature and efficient. Zapata, Fortenbery and Armstrong (2005) examine the observations from January 1990 to January 1995 of 11 future prices traded in New York and the World cash prices for exported sugar. They report that future markets for sugar leads the cash market in price discovery. A unidirectional causality from future price to spot is revealed. Futures and cash prices are found to be co-integrated which suggests the sugar futures contract is a useful vehicle for reducing overall market price risk faced by cash market participants selling at the world price. In a study conducted by Silvapulle and Moosa (1999) and Karande (2006) a lead is found in the futures prices implying the price is being discovered first in that market and latter in the spot market. It is found that futures prices play a dominant role and the future prices of crude oil and castor seed lead spot prices. Primarily why a lead-lag relationship between the two markets is observed is that it is less costly since transaction cost is lower and the degree of leverage attainable is higher.

Fu and Qing (2006) study the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen co-integration, VECM and bivariate EGARCH model. The results show there is a long-term equilibrium relationship and significant bidirectional information flows between spot and futures markets in China, with a dominant role played by futures markets. Although innovations in one market could predict futures volatility in another market, the volatility spillovers from futures to spot are more significant than the other way round. Dash, Andrews (2010) examine the market behavior and causality effects between spot and futures prices in Indian commodity markets. The pattern is quite different for different commodities. Commodities that suffer from chronic backwardation must be analyzed in more detail, in order to understand the causes, and controls (known as backwardation limits) should be instituted for the same. Causality in commodities markets can be used to either hedge or speculate price movements: if changes in spot prices drive changes in futures prices, efficient hedging strategies can be formulated; whereas if changes in futures prices impel change in spot prices, efficient speculation strategies can be developed. Further, causality can be used in forecasting commodity spot and futures prices.

As mentioned above, empirical literature on price discovery and volatility spillover mainly deals with developed markets like US and UK. In India significant and relevant literature on commodity market is thin and has mainly focussed on agricultural commodities (Kabra, (2007; Kolamkar, (2003); Kumar and Pandey, (2009); Naik and Jain, (2002); Ramaswami and Singh, (2007); Raipuria, (2002); Roy, (2008); Sabnavis and Jain, 2007; Thomas, 2003; Nair, 2004, Ghosh (2009a), (2009b), (2010a), Pavaskar (2009) and Pavaskar and Ghosh (2009), Dey, (2009); Dey and Maitra, (2011)). Further the Indian literature is limited to regional exchanges, dated/small samples form the period prior to setting up national exchanges, or to few commodities traded on national exchanges (Thomas and Karande, 2001; Naik and Jain, 2002; Roy, 2008; and Roy and Dey, 2009). This paper examines if the India futures market effectively serves the price discovery function, and that the introduction of futures trading has resulted volatility in the underlying spot market.

DATA AND METHODOLOGY

The sample used in the study consists of thirteen commodities (basket of agricultural, metal and energy products) which are most actively traded on Multi Commodity Exchange (MCX) Mumbai. The period of study is from November 2003-to March 2011 however the data period varies across commodities owing to their late introduction on trading exchanges and the fact that some agricultural commodities were banned from trading for a certain period to curb speculative impacts which according to policy makers could have triggered high inflation. The data comprises of daily closing spot and futures prices of the sample commodities. The natural logarithm of daily prices is taken to minimize the heteroscedasticity in data. Middle month prices are taken into account as in this period trading volumes are highest. Besides individual commodities, four futures indices and corresponding underlying spot indices as shown have been used. These indices are applied to examine the aggregate behaviour of commodities as well as commodity classes with regards to price discovery and volatility spillover effects. The list of sample indices and commodities as well as their data period is given in the following Table 1.

Table 1: List of Sample Indices and Commodities

Indexes	Agriculture	Metal	Energy
Mcx-Comdex	Chana	Gold	Naturalgas
Mcx-Agri-Index	Guar Seed	Silver	Crudeoil
Mcx-Metal-Index	Soybean	Zinc	
Mcx-Energy-Index	Kapas	Lead	
	Potato Agra	Copper	

The table shows the sample commodity and indices used in the study. The period of study is from November 2003-to March 2011 however the data period varies across commodities. The sample consists of four indices and basket of commodity comprising of Metal, Energy and agricultural commodities.

Given the nature of the problem and the quantum of data, we first study the data properties from an econometric perspective and find that co-integration and error correction models are required to establish the equilibrium relationship between the markets. Further, to quantify and study volatility spillover, we use bivariate EGARCH framework which is covered in the next section. To test the causality block exogeneity test is performed and the findings are provided in detail in results section. The regression analysis would yield efficient and time invariant estimates provided the variables are stationary over time. However, many financial and macroeconomic time series behave like a random walk. We first test whether or not the spot and futures price series are co-integrated. The concept of co-integration becomes relevant when the time series being analyzed are non stationary. The time series stationarity of sample price series has been tested using Augmented Dickey Fuller (ADF) 1981. The ADF test uses the existence of a unit root as the null hypothesis. To double check the robustness of the results, Phillips and Perron (1988) test of stationarity has also been performed for the series.

RESULTS

The results of stationarity tests are given in Table 2. It confirms non stationarity of commodity price data; hence we repeat stationarity tests on return series (estimated as first difference of log prices) which are also provided in Table 2. The table describes the sample price series that have been tested using Augmented Dickey Fuller, (ADF) 1981. The ADF test uses the existence of a unit root as the null hypothesis. To double check the robustness of the results, Phillips and Perron (1988) test of stationarity has also been performed for the price series and then both the test are performed on return series. Panel A and Panel B report results of indices and commodities respectively. The sample return series exhibit stationarity thus conforming that both spot and future commodity prices are integrated to the first order.

If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series is said to be co-integrated. Given that each commodity spot and futures prices are integrated of the same order, co-integration techniques are used to determine the existence of a stable long-run relationship between price pairs. Arrival of new information results in price discovery for short intervals of time between futures and spot market due to communication costs. Increased availability and lower cost of information account together for faster assimilation of information in the futures market than a spot market (Koontz *et al*., 1990).

The price linkage between futures market and spot market is examined using cointegration (Johansen, 1991) analysis that has several advantages. First, cointegration analysis reveals the extent to which two markets move together towards long run equilibrium. Secondly, it allows for divergence of respective markets from long-run equilibrium in the short run. The co-integrating vector identifies the existence of long run equilibrium, while error correction dynamics describes the price discovery process that helps the markets to achieve equilibrium (Schreiber and Schwartz, 1986). Co-integrating methodology fundamentally proceeds with non-stationary nature of level series and minimizes the discrepancy that arises from the deviation of long-run equilibrium. The observed deviations from long-run equilibrium are not only guided by the stochastic process and random shocks in the system but also by other forces like arbitrage process. As a result, the process of arbitrage possesses dominant power in the commodity future market to minimize the very likelihood of the short run disequilibrium. Moreover, it is theoretically claimed that if futures and spot price are coinetgrated, then it implies presence of causality at least in one direction. On the other hand, if some level series are integrated of the same order, it does not mean that both level series are coinetgrated. Cointegration implies linear combinations of both level series cancelling the stochastic trend, thereby producing a stationary series.

Johansen's cointegration test is more sensitive to the lag length employed. Besides, inappropriate lag length may give rise to problems of either over parameterization or underparametrisation. The objective of the estimation is to ensure that there is no serial correlation in the residuals. Here, Akaike information criterion (AIC) is used to select the optimal lag length and all related calculations have been done mbedding that lag length. The cointegration results are reported in Table 3. Panel A and Panel B report results of indices and commodities respectively.

Table 2: Stationarity Test for Sample Indices and Commodities

	Price- Series		Inference On Return Series Integration I (I)	
	ADF Test	**Phillips-Perron Test**	**ADF Test**	**Phillips-Perron Test**
Panel A: INDICES	**t-statistics**	**t-statistics**	**t-statistics**	**t-statistics**
MCX-COMDEX				
(A)FUTURE PRICES	-1.09	-0.51	-41.98 **	-41.98 **
(B) SPOT PRICES	1.12	-1.38	-41.35 **	-41.32 **
MCX-AGRI-INDEX				
(A) FUTURE-PRICE	0.78	0.65	-32.96 **	-42.7 **
(B)SPOT-PRICE	0.43	1.38	-40.24 **	-40.41 **
MCX-METAL-INDEX				
(A)FUTURE-PRICE	-1.17	0.096	-44.07**	-44.17 **
(B)SPOT-PRICE	-0.1	0.44	-44.08 **	-44.09 **
MCX-ENERGY-INDEX				
(A)FUTURE-PRICE	-1.59	-1.73	-40.2 **	-40.21 **
(B)SPOT-PRICE	-1.9	-2.38	-46.24 **	-46.28 **
Panel B: COMMODITIES	**t-statistics**	**t-statistics**	**t-statistics**	**t-statistics**
CHANA				
(A)FUTURE-PRICE	-2.42	-2.46	-40.85 **	-40.82 **
(B)SPOT-PRICE	-2.41	-2.32	-40.62 **	-40.62 **
GUAR SEED				
(A)FUTURE-PRICE	-2.19	-2.17	-36.5 **	-36.51 **
(B)SPOT-PRICE	-1.1	-1.3	-24.9 **	-42.18 **
SOYBEAN				
(A)FUTURE-PRICE	-0.57	-0.53	-26.75 **	-26.74 **
(B)SPOT-PRICE	-0.42	-0.42	-27.76 **	-27.71 **
KAPAS				
(A)FUTURE-PRICE	0.81	0.69	-34.95 **	-34.95 **
(B)SPOT-PRICE	-0.1	-0.16	-36.44 **	-36.45 **
POTATO AGRA				
(A)FUTURE-PRICE	-2.67	-2.67	-36.33 **	-36.33 **
(B)SPOT-PRICE	1.85	3.09	-8.36 **	-36.84 **
GOLD				
(A)FUTURE-PRICE	0.36	0.4	-42.47 **	-42.47 **
(B)SPOT-PRICE	-0.35	-0.32	-43.76 **	-43.76 **
SILVER				
(A)FUTURE-PRICE	-0.84	-0.93	-44.68 **	-44.68 **
(B)SPOT-PRICE	-0.711	-0.78	-46.54 **	-46.49 **
ZINC				
(A)FUTURE-PRICE	-1.37	-1.36	-38.9 **	-38.92 **
(B)SPOT-PRICE	-1.51	-1.47	-44.67 **	-45.14 **
LEAD				
(A)FUTURE-PRICE	-1.92	-2.02	-34.33 **	-34.4 **
(B)SPOT-PRICE	-1.92	-2.02	-37.57 **	-37.58 **
COPPER				
(A)FUTURE-PRICE	-0.84	-0.93	-44.66 **	-44.65 **
(B)SPOT-PRICE	-0.71	-0.78	-46.39 **	-46.65 **
NATURALGAS				
(A)FUTURE-PRICE	-1.73	-1.7	-38.97 **	-38.98 **
(B)SPOT-PRICE	-1.81	-2.22	-28.28 **	-63.68 **
CRUDEOIL				
(A)FUTURE-PRICE	-1.81	-2.22	-28.28 **	-63.68 **
(B)SPOT-PRICE	-1.73	-1.7	-38.97 **	-38.98**

The table describes the sample price series that have been tested using Augmented Dickey Fuller (ADF) 1981. The ADF test uses the existence of a unit root as the null hypothesis. To double check the robustness of the results, Phillips and Perron (1988) test of stationarity has also been performed for the price series and then both the test are performed on return series also as shown in Panel-A (price series) and Panel B (Return series) are integrated to I(1). All tests are performed using 5%level of significance (**).

Table 3: Johansen's Co-Integration Test

	Lag Length	Max Eigen Value	Trace Statistic	Critical Value**
Panel A: Indices				
MCX-COMDEX				
(A)FUTURE PRICES	5 lags*	37.78	39.53	**15.49**
(B) SPOT PRICES		1.75	1.75	**3.84**
MCX-AGRI-INDEX				
(A) FUTURE-PRICE	4 lags*	11.76	12	15.49
(B)SPOT-PRICE		0.24	0.24	3.84
MCX-METAL-INDEX				
(A)FUTURE-PRICE	2 lags*	27.86	28.67	**15.49**
(B)SPOT-PRICE		0.81	0.81	**3.84**
MCX-ENERGY-INDEX				
(A)FUTURE-PRICE	4 lags*	77.99	82.58	**15.49**
(B)SPOT-PRICE		4.59	4.59	**3.84**
Panel B: Commodities				
CHANA				
(A)FUTURE-PRICE	3 lags*	57.59	62.41	**15.49**
(B)SPOT-PRICE		4.82	4.82	**3.84**
GUAR SEED				
(A)FUTURE-PRICE	5 lags*	28.4	29.85	**15.49**
(B)SPOT-PRICE		1.44	1.44	**3.84**
SOYBEAN				
(A)FUTURE-PRICE	2 lags*	77.54	77.69	15.49
(B)SPOT-PRICE		0.14	0.14	3.84
KAPAS				
(A)FUTURE-PRICE	3 lags*	10.59	12.01	15.49
(B)SPOT-PRICE		1.422	1.42	3.84
POTATO AGRA				
(A)FUTURE-PRICE	5 lags*	3.3	3.74	15.49
(B)SPOT-PRICE		0.43	0.43	3.84
GOLD				
(A)FUTURE-PRICE	2 lags*	9.65	9.66	15.49
(B)SPOT-PRICE		0	0	3.84
SILVER				
(A)FUTURE-PRICE	2 lags*	8.17	9.66	15.49
(B)SPOT-PRICE		1.48	1.48	3.84
ZINC				
(A)FUTURE-PRICE	2 lags*	300.6	302.56	**15.49**
(B)SPOT-PRICE		1.961	1.96	**3.84**
LEAD				
(A)FUTURE-PRICE	3 lags*	167.94	172.37	**15.49**
(B)SPOT-PRICE		4.42	4.42	**3.84**
COPPER				
(A)FUTURE-PRICE	7 lags*	65.13	69.66	**15.49**
(B)SPOT-PRICE		4.52	4.52	**3.84**
NATURALGAS				
(A)FUTURE-PRICE	2 lags*	337.06	339.86	**15.49**
(B)SPOT-PRICE		2.8	2.8	**3.84**
CRUDEOIL				
(A)FUTURE-PRICE	4 lags*	177	181.65	**15.49**
(B)SPOT-PRICE		4.64	4.64	**3.84**

This table provides the Johansen's co-integration test, maximal Eigen value and Trace test statistics are used to interpret whether null hypothesis of r=0 is rejected at 5 % level and not rejected where r=1. Rejection of null hypothesis implies that there exists at least one co-integrating vector which confirms a long run equilibrium relationship between the two variables, spot and future prices in our case. The null hypothesis is rejected in case of eight commodities (Chana, Guarseed, Soybean, Zinc, Lead, Copper, Natural Gas, Crude oil) and three indices (MCX Comdex, MCX Metal, MCX Energy), which reveals that one cointegration relationship exists between spot and futures prices.

Maximal Eigen value and trace test statistics are used to interpret whether null hypothesis of r =0 is rejected at 5% level and not rejected when r =1. Rejection of the null hypothesis implies there exists at least one co-integrating vector which confirms a long run equilibrium relationship between the two variables, spot and future prices in our case. The null hypothesis is rejected in case of eight commodities (Chana, Guarseed, Soybean, Zinc, Lead, Copper, Natural Gas, Crude oil) and three indices (MCX Comdex, MCX Metal, MCX Energy), Which reveals that one cointegration relationship exists between spot and futures prices. Thus, spot and futures prices of these commodities and indices share common long-run information.

Our cointegration result confirm that in general there is a price discovery process in the spot and future commodity markets. Despite determining a co integrating vector for each commodity/index, it is customary to produce the diagnostic checking criterions before estimating the ECM model. Diagnostic tests are performed for those commodities and indices for which long run relationship between spot and future prices is confirmed based on Johnson cointegration test. Vector Auto Regression (VAR) estimated with various lags selected by AIC is used to check whether the model satisfies the stability, normality test as well as no serial correlation criterion among the variables in the VAR Adequacy model. Testing the VAR adequacy of the sample series as shown in Table 4, it was revealed that all the sample commodities and indexes are satisfying the stability test except MCX Metal Index. In normality test all the sample commodities are found to be normal. In verifying the VAR Residual Serial Correlation LM Tests it was found that in all eleven sample series no serial correlation was present. Therefore, it leads to take the position that our model fulfils the adequacy criterion for majorly almost all commodities which exhibited a long run relationship between spot and futures prices as shown by Johansson Cointegration Test. Panel A and Panel B report results of indices and commodities respectively.

The error correction model takes into account the lag terms in the technical equation that invites the short run adjustment towards the long run. This is the advantage of the error correction model in evaluating price discovery. The presence of error correction dynamics in a particular system confirms the price discovery process that enables the market to converge towards equilibrium. In addition, the model shows not only the degree of disequilibrium from one period that is corrected in the next, but also the relative magnitude of adjustment that occurs in both markets in achieving equilibrium. Moreover, cointegration analysis indicates how two markets (such as futures and spot commodity markets) reveal pricing information identified through the price difference between the respective markets. The implication of cointegration is that the commodities in two separate markets respond disproportionately to the pricing information in the short run, but they converge to equilibrium in the long run under the condition that both markets are innovative and efficient. In other words, the root cause of disproportionate response to the market information is that a particular market is not dynamic in terms of accessing the new flow of information and adopting better technology. Therefore, there is a consensus that price changes in one market (futures or spot commodity market) generates price changes in the other market (spot or commodity futures) with a view to bring a long run equilibrium relation is :

$$F_t = \alpha + \beta S_t + \varepsilon_t \tag{1}$$

Equation (1) can be expressed as in the residual form as: ệ

$$F_t - \alpha - \beta S_t = \hat{e}\, t \tag{2}$$

In the above equations F_t and S_t are futures and spot prices of a commodity in the respective market at time t. Both α and β are intercept and coefficient terms, where as $\hat{e}_t$ is estimated white noise disturbance term. The main advantage of cointegration is that each series can be represented by an error correction model which includes last period's equilibrium error with adding intercept term as well as lagged values of first difference of each variable. Therefore, casual relationship can be gauged by examining the statistical significance and relative magnitude of the error correction coefficient and coefficient on lagged variable. Hence, the error correction model is:

$$\Delta F_t = \delta_f + \alpha_f \hat{e}_{t-1} + \beta_f \Delta F_{t-1} + Y_f \Delta S_{t-1} + \varepsilon_{ft} \quad (3)$$

$$\Delta S_t = \delta_s + \alpha_s \hat{e}_{t-1} + \beta_f \Delta S_{t-1} + Y_f \Delta F_{t-1} + \varepsilon_{St} \quad (4)$$

Table 4: Adequacy Test for VAR Model

Future Price & Spot Price Panel A: Indices		Var Adequacy Test	Critical Values	Lags
MCX-COMDEX	1	Stability (modulus values of roots of characteristics polynomials)	0.94, 0.89, 0.24, 0.08 (Stable)	5*
	2	Normality Chi-Square values	4.81 (Jarque-Bera) p Val (0.09)(Normal)	5*
	3	Serial Correlation LM-Test	18.55(p Val 0.08) (no serial correlation)	5*
MCX-METAL-INDEX	1	Stability (modulus values of roots of characteristics polynomials)	1.00 (Not Stable)	4*
	2	Normality Chi-Square values	10114.07 (p Val 0.07) (Normal)	4*
	3	Serial Correlation LM-Test	1.27 (p Val 0.86) (No Serial Correlation)	4*
MCX-ENERGY-INDEX	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.90,0.49, 0.49 (Stable)	4*
	2	Normality Chi-Square values	338.56 (p Val 0.06) (Not Normal)	4*
	3	Serial Correlation LM-Test	13.01 (p Val 0. 10) (no Serial correlation)	4*
Panel B: Commodities				
CHANA	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.77, 0.26, 0.09 (Stable)	3*
	2	Normality Chi-Square values	4096.64 (p Val 0.12) (Normal)	3*
	3	Serial Correlation LM-Test	17.76 (p Val 0.09) (no serial correlation)	3*
GUAR SEED	1	Stability (modulus values of roots of characteristics polynomials)	0.94, 0.99,0.88, 0.30, 0.01 (stable)	2*
	2	Normality Chi-Square values	20462.09 (p Val 0.090) (Normal)	2*
	3	Serial Correlation LM-Test	9.85 (p Val 0.09) (no serial correlation)	2*
SOYA BEAN	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.75, 0.20, 0.37(Stable)	2*
	2	Normality Chi-Square values	37017.36 (p Val 0.18) (Normal)	2*
	3	Serial Correlation LM-Test	2.28, p Val (0.19) (No Serial correlation)	2*
ZINC	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.55, 0.41, 0.11, 0.01(Stable)	2*
	2	Normality Chi-Square values	321.09 (p Val 0.08) (Normal)	2*
	3	Serial Correlation LM-Test	16.14, p Val (0.12) (no serial correlation)	2*
LEAD	1	Stability (modulus values of roots of characteristics polynomials)	0.99,0.64,0.25,0.24, 0.21,0.21 (Stable)	3*
	2	Normality Chi-Square values	615.69 (p Val 0.08) (Normal)	3*
	3	Serial Correlation LM-Test	1.61 (p Val 0.81) (No Serial Correlation)	3*
9.COPPER	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.69, 0.14, 0.9 (Stable)	2*
	2	Normality Chi-Square values	28959.2 (p Val 0.0801) (Normal)	2*
	3	Serial Correlation LM-Test	24.04 (p Val 0.12) (no serial correlation)	2*
10.NATURALGAS	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.33, 0.23, 0.00 (Stable)	2*
	2	Normality Chi-Square values	20019389 (p Val 0.12) (Normal)	2*
	3	Serial Correlation LM-Test	7.35 (p Val 0.12) (No Serial Correlation)	2*
11.CRUDEOIL	1	Stability (modulus values of roots of characteristics polynomials)	0.99, 0.54, 0.15, 0.05 (Stable)	4*
	2	Normality Chi-Square values	4175.11 (p Val 0.07) (Normal)	4*
	3	Serial Correlation LM-Test	5.08 (p Val 0.28)(no serial correlation)	4*

The asterisk (*) shows significance at 1, 2, 3 and 4 lags. Diagnostic tests are performed for sample commodities and indices. Vector Auto Regression (VAR) estimated with various lags selected by AIC is used to check whether the model satisfies the stability, normality test as well as no serial correlation criterion among the variables in the VAR Adequacy model. Results reveal that all the sample commodities and indexes are satisfying the stability test except MCX Metal Index. In normality test all the sample commodities are found to be normal. In verifying the VAR Residual Serial Correlation LM Tests it was found that in all eleven sample series no serial correlation was present. Therefore, it leads us to take the position that our model fulfils the adequacy criterion for majorly almost all commodities.

In the above two equations, the first part $\hat{e}_{t-1}$ is the equilibrium error which measures how the dependent variable in one equation adjusts to the previous period's deviation that arises from long run equilibrium. The remaining part of the equation is lagged first difference which represents the short run effect of previous period's change in price on current period's deviation. The coefficients of the equilibrium error, α_f and α_s signify the speed of adjustment coefficients in future and spot commodity markets that claim significant implication in an error correction model. At least one coefficient must be non zero for the model to be an error correction model (ECM). The coefficient acts as evidence of direction of casual relation and reveals the speed at which discrepancy from equilibrium is corrected or minimized. If, α_f is statistically insignificant, the current period's change in future prices does not respond to last period's deviation from long run equilibrium. If both, α_f and β_f are statistically insignificant; the spot price does not Granger cause futures price. The justification of estimating ECM is to know which sample markets play a crucial role in price discovery process.

The Vector Error Correction Model (VECM) results are reported in Table 5. It shows short run dynamics in the price series and price movements in the two markets. The lag length of the series is selected in Vector Error Correction Model (VECM) on the basis of Akaike's Information Criteria. The residual diagnostics tests; indicate existence of Heteroscedasticity, in most of the sample commodities and indices which exhibit cointegration. Thus, t-statistics are adjusted, as well as the Wald test statistics which are employed to test for Granger causality, by the White (1980) heteroscedasticity correction.

After correction, we reestimate VECM. The empirical results show that in the VECM model, error correction coefficients are significant in both equations (1) and (2) with correct signs, suggesting a bidirectional error correction in relevant commodities and indices. Error Correction Terms (ECTS) also known as mean- reverting price process, provide insights into the adjustment process of spot and future prices towards long run equilibrium. For the entire period, coefficients of the ECTs are statistically significant between one to two lags, in both equations of spot and future markets as suggested by Akaike Information Criterion (AIC). This implies that once the price relationship of spot and futures market deviates away from the long-run coinetgrated equilibrium, both markets will make adjustments to re-establish the equilibrium condition during the next period except with little drifts in one or two lags of the sample commodities. The results reveal that error correction term of spot market in ten out of eleven commodities/indices is greater in magnitude than that of future market which implies that spot price makes greater adjustment in order to re-establish the equilibrium. In other words, future price leads the spot (cash) price in price discovery mechanism. Natural Gas is the only exception where ECT is larger for futures than for the spot price. Panel A and Panel B report results of indices and commodities respectively.

In addition, the empirical results of VEC Granger Causality/Bloc Exogeneity Wald test between spot and futures markets were examined to check the direction of causality. The results of VEC Granger causality test are provided in Table 6. There are bi-directional Granger lead relationships between spot and futures in the MCX-Energy Index, Chana, Zinc, Lead, Copper, Crude oil and single Granger lead relationships from futures to spot in the Comdex Index which are significant at 5% level. There was no causality found in three out of eight commodities: Guar seed ,Soybean and Natural Gas and one out of three indices: MCX metal Index. MCX Metal index failed in VAR Adequacy test thereby implying that the observable cointegration in its case may actually be weak. These empirical results are consistent with the co-integrating relationships above. To reconfirm the empirical results of which market whether spot or futures markets have the ability of price discovery and validate the dominant role of the futures in price discovery, Variance Decomposition Analysis is done. The Variance Decomposition Analysis measures the percentage of the forecast error of a variable that is explained by another variable. It indicates the relative impact that one variable has upon another variable within the VECM system.

Table 5: The Empirical Results of Error Terms

Panel A: INDEXES	COMDEX		MCXMETAL		MCXENEY	
CointEq1	ΔFT	ΔST	ΔFT	ΔST	ΔFT	ΔST
Error Correction:	-0.12**	0.12**	-0.27**	2.17**	-0.17**	-0.18**
standard error () and t-stats []	(-0.01) [-6.63]	(-0.01) [6.64]	(-0.05) [-5.07]	(-0.42) [5.03]	(-0.01) [10.75]	(-0.01) [-10.77]
D (FUTURES PRICE (-1))	-34.75**	35.18	-0.24	1.88	-12.57**	13.58**
standard error () and t-stats []	(-4.45) [-7.80]	(-4.48) [7.85]	(-0.13) [-1.84]	(-1.04) [1.79]	(-1.95) [-6.43]	(-2.08) [6.51]
D (FUTURES PRICE (-2))	-28.05**	28.4**	0.01	-0.15	-8.74**	9.4**
standard error () and t-stats []	(-4.56) [-6.14]	(-4.59) [6.18]	(-0.13) [0.13]	(-1.04) [-0.14]	(-1.97) [-4.42]	(-2.10) [4.46]
D (SPOT PRICES (-1))	-33.99**	34.42**	-1.98	15.19	-8.74**	9.4**
standard error () and t-stats []	(-4.41) [-7.69]	(-4.44) [7.73]	(-1.04) [-1.89]	(-8.22) [1.84]	(-1.97) [-4.42]	(-2.10) [4.46]
D (SPOT PRICES (-2))	-27.57**	27.92**	0.11	-1.04	-7.98**	8.58**
standard error () and t-stats []	(-4.52) [-6.09]	(-4.557) [6.13]	(-1.04) [0.11]	(-8.22) [-0.12]	(-1.84) [-4.31]	(-1.97) [4.35]
C	0	0	0	0	0	0
standard error () and t-stats []	0 [0.65]	(-0.00) [0.90]	(-0.00) [-0.29]	(-0.00) [2.20]	0 [0.31]	(-0.00) [-0.31]
Panel B: COMMODITIES	**CHANA**		**GUARSEED**		**SOYBEAN**	
CointEq1	ΔFT	ΔST	ΔFT	ΔST	ΔFT	ΔST
Error Correction:	-0.06**	0.06**	-0.09**	0.09**	-0.27**	0.27**
standard error () and t-stats []	(-0.00) [7.97]	(-0.00) [-7.95]	(-0.01) [-7.14]	(-0.01) [7.09]	(-0.03) [-9.01]	(-0.03) [9.01]
D (FUTURES PRICE (-1))	-2.35**	2.5	1.1**	-1.32	8.64**	-8.85**
standard error () and t-stats []	(-1) [-2.34]	(-1) [2.48]	(-0.66) [1.65]	(-0.68) [-1.65]	(-4.16) [2.07]	(-4.27) [-2.07]
D (FUTURES PRICE (-2))	2.81**	-2.83**'	0.64	-0.65	2.8	-2.87
standard error () and t-stats []	(-0.99) [2.82]	(-0.99) [-2.84]	(-0.66) [0.97]	(-0.67) [-0.96]	(-4.15) [0.67]	(-4.26) [-0.67]
D (SPOT PRICES (-1))	-2.63	2.77	1.39	-1.43	8.56	-8.76
standard error () and t-stats []	(-1) [-2.61]	(-1) [2.76]	(-0.64) [2.15]	(-0.66) [-2.15]	(-4.05) [2.11]	(-4.16) [-2.10]
D (SPOT PRICES (-2))	-2.67	2.78	1.40	-1.45	8.68	-8.90
standard error () and t-stats []	(-0.99) [2.80]	(-0.99) [-2.83]	(-0.64) [1.24]	(-0.65) [-1.2]	(-4.04) [0.67]	(-4.15) [-0.67]
C	0	0	0	0	0	0
standard error () and t-stats []	0 [0.03]	0 [-0.01]	0 [-0.01]	0 [0.04]	0 [-0.02]	0 [0.04]
METAL	**ZINC**		**LEAD**		**COPPER**	
CointEq1	ΔFT	ΔST	ΔFT	ΔST	ΔFT	ΔST
Error Correction:	-0.19	0.19	-0.2	0.2	0.28	-0.28
standard error () and t-stats []	(-0.01) [-17.18]	(-0.01) [17.20]	(-0.01) [-14.42]	(-0.01) [14.43]	(-0.02) [10.68]	(-0.03) [-10.70]
D (FUTURES PRICE (-1))	-14.07	14.29	-11.47	11.83	-81.8332	81.12
standard error () and t-stats []	(-5.93) [-2.37]	(-5.99) [2.38]	(-3.28) [-3.49]	(-3.35) [3.52]	(-7.34) [-11.13]	(-7.25) [11.17]
D (FUTURES PRICE (-2))	-12.25	12.41	0.01	0.05	-40.6	40.31
standard error () and t-stats []	(-5.93) [-2.06]	(-5.99) [2.07]	(-3.29) [0.00]	(-3.36) [0.01]	(-7.59) [-5.34]	(-7.5) [5.37]
D (SPOT PRICES (-1))	-13.79	14	-11.07	11.42	-81.36	80.65
standard error () and t-stats []	(-5.86) [-2.35]	(-5.92) [2.36]	(-3.21) [-3.44]	(-3.28) [3.48]	(-7.26) [-11.19]	(-7.17) [11.23]
D (SPOT PRICES (-2))	-12.06	12.21	0.04	0.02	-40.3	40.01
standard error () and t-stats []	(-5.86) [-2.05]	(-5.92) [2.06]	(-3.21) [0.01]	(-3.29) [0.00]	(-7.52) [-5.35]	(-7.43) [5.38]
C	0	0	0	0	0	0
standard error () and t-stats []	(0) [-0.10]	(0) [0.10]	(0) [0.11]	(-0.00) [-0.11]	(-0.00) [0.80]	(0) [-0.79]
ENERGY	**NATURAL GAS**		**CRUDEOIL**			
CointEq1	ΔFT	ΔST	ΔFT	ΔST		
Error Correction:	-0.16	0.17	-0.27	0.28		
standard error () and t-stats []	(-0.01) [-16.74]	(-0.01) [16.87]	(-0.03) [-11.09]	(-0.03) [11.14]		
D (FUTURES PRICE (-1))	-0.73	0.74	-27.14	27.64		
standard error () and t-stats []	(-2.03) [-0.36]	(-2.03) [0.36]	(-5.15) [-5.26]	(-5.18) [5.33]		
D (FUTURES PRICE (-2))	-3.39	3.43	-28.47	28.67		
standard error () and t-stats []	(-2.03) [-1.67]	(-2.03) [1.68]	(-5.18) [-5.48]	(-5.21) [5.49]		
D (SPOT PRICES (-1))	-0.58	0.59	-26.56	27.05		
standard error () and t-stats []	(-2) [-0.29]	(-2.01) [0.29]	(-5.11) [-5.19]	(-5.13) [5.26]		
D (SPOT PRICES (-2))	-3.31	3.35	-28.12	28.32		
standard error () and t-stats []	(-2) [-1.65]	(-2.01) [1.66]	(-5.13) [-5.48]	(-5.16) [5.48]		
C	0	0	0	0		
standard error () and t-stats []	0 [-0.03]	(-0.00) [0.02]	(-0.00) [0.26]	0 [-0.26]		

This table exhibits short run dynamics using VECM MODEL using Akaike's Information Criteria. The error correction coefficients are significant suggesting a bidirectional error correction and future price leads the spot price with exception of Natural Gas. A (**) is significant at 5%.

The variance decomposition enables us to assess the economic significance of these impacts as the percentages of the forecast error for a variable sum to one. This structure of result showing the information share shows that most of the price changes of spot and futures are because of futures market, and more information flows from futures to spot. The information share and variance decomposition confirms the dominant role of futures in price discovery, the results of which are also shown in Table 6. Panel A and Panel B report results of indices and commodities respectively. The findings clearly indicate that in Comdex, MCX Metal, MCX energy, Chana, Guarseed, Soybean, Zinc, Lead, Copper and Natural Gas there is a dominant role of futures market and information flows from futures to spot.

Table 6: The Empirical Results of Variance decomposition analysis and Granger Lead Analysis

	Causality Test					
Panel A: INDEXES	**COMDEX**		**MCXMETAL**		**MCXENEY**	
Variance decomposition analysis	83.63%	16.92%	99.68%	0.32%	94.00%	6%
Block exogenity tests	DV: future price	DV: spot price	DV: future price	DV: spot price	DV: future price	DV: spot price
VAR Granger Causality/Block Exogeneity Wald Tests	P(0.45)	P(0.00)	P(0.11)	P(0.11)	P(0.00)	P(0.00)
Panel B: COMMODITIES	**CHANA**		**GUARSEED**		**SOYBEAN**	
	99.30%	0.70%	99.20%	0.80%	99.50%	0 .5%
Variance decomposition analysis	DV: future price	DV: spot price	DV: future price	DV: spot price	DV: future price	DV: spot price
VAR Granger Causality/Block Exogeneity Wald Tests	P(0.00)	P(0.00)	P(0.08)	P(0.15)	P(0.08)	P(0.09)
METAL	**ZINC**		**LEAD**		**COPPER**	
	99.20%	0.80%	98.80%	0.20%	83.95%	16.05%
Variance decomposition analysis	DV: future price	DV: spot price	DV: future price	DV: spot price	DV: future price	DV: spot price
Var granger Causality/Block Exogeneity test	P(0.0054)	P(0.00049)	P(0.005)	P(0.0000)	P(0.0002)	P(0.0000)
ENERGY	**NATURAL GAS**		**CRUDEOIL**			
	99.75%	0.30%	94%	6%		
Variance decomposition analysis	DV: future price	DV: spot price	DV: future price	DV: spot price		
Var granger Causality/Block Exogeneity test	P(0.24)	P(0.24)	P(0.00)	P(0.00)		

The results of Table 5 are reconfirmed in this table by Variance Decomposition Analysis. There are bi-directional Granger lead relationships between spot and futures in the MCX-Energy Index, Chana, Zinc, Lead, Copper, Crude oil and single Granger lead relationships from futures to spot in the Comdex Index.

In sum the results confirm a price discovery process for most commodities and indices with a dominant role of futures market further the spot market makes greater adjustments to restore long run equilibrium relationship between future and spot market. The findings are in conformity with prior research and seem rational on the ground that futures exchanges in India involve electronic trading system experiencing high trading volumes, while spot market are physical in nature and generally not automated. They also do not experience high trading volumes which in turn are seasonal in character for some commodities. This makes futures market more informational efficient and cost competitive thus ensuring their lead role in price discovery.

BIVARIATE EGARCH MODEL AND VOLATILITY SPILLOVER

In this section, we evaluate if there is volatility spillover between future and spot market for the sample commodities. Volatility spillover reveals that future trading could intensify volatility in the underlying spot market due to the larger trading program and the speculative nature of the future trading. The volatility spillovers hypothesis involves testing for the lead-lag relations between volatilities in the futures and spot markets. Clearly, reliable tests require common good measure of volatilities. Bollerslev's (1986) generalize autoregressive conditional heteroscedasticity (GARCH) model cannot be used due to certain regularities where it assumes that positive and error terms have a symmetric effect on the volatility. In other words, good news (market advances) and bad news (market retreats) have the same effect on the volatility in this model. This implies that the leverage effect (price rise and fall) is neutralized in this model. The second regularity is that all coefficients need to be positive to ensure that the conditional variance is never negative (i.e. measure of risk). To overcome these weaknesses of the GARCH model in handling financial time series, Nelson's (1991) exponential GARCH (EGARCH) model is used in order to capture the asymmetric impacts of shocks or innovations on volatilities and to avoid imposing non-negativity restrictions on the values of GARCH parameters. There are many studies in which symmetries in stock return are documented [e.g., Nelson (1991), Koutmos and Booth (1995), Koutmos and Tucker (1996), Engle and Ng (1993), and Glosten *et al*. (1993)].

In this study, the estimation process is concentrated on the direct spillover between futures and spot markets volatility. The empirical analysis reported here is based on two-stage estimation. The first step is to apply VECM and the second step is to use the residuals of VECM in the bivariate EGARCH model. This two step approach (the first step for the VECM and the second step for the bivariate EGARCH model is asymptotically equivalent to a joint estimation for the VECM and EGARCH models (Greene, 1997). Estimating these two models simultaneously in one step is not practical because of the large number of parameters involved. Our EC-EGARCH model allows the conditional volatilities and covariance to adjust to deviations from long-run price disequilibria, whereas traditional EGARCH models do not. As such, the model facilitates the testing of both short run and long run volatility spillovers hypotheses. The EC-EGARCH model may further prove useful for portfolio managers in formulating optimal hedging strategies. Some studies e.g., Yang, Bessler, and Leatham (2001) emphasize the need to incorporate any existing cointegration between spot and futures prices into hedging decisions, while others such as Lien and Lou (1994) underscore the importance of GARCH effects in such decisions.
We use the following EGARCH MODEL

$$\ln(\sigma^2_{ft}) = \beta_{ff}(e^2 f_{t-1}) + \beta_{fs}(e^2 s_{t-1}) + \Upsilon_f(\sigma^2 f_{t-1}) \quad (5)$$

$$\ln(\sigma^2_{st}) = \beta_{ss}(e^2 s_{t-1}) + \beta_{sf}(e^2 f_{t-1}) + \Upsilon_f(\sigma^2 s_{t-1}) \quad (6)$$

The unrelated residuals e_{ft} and e_{st} are obtained from the equations (3) and (4). This two step approach (the first step for the VECM and the second step for the bivariate EGARCH model is asymptotically equivalent to a joint estimation for the VECM and EGARCH models (Greene, 1997).

Before estimating the EGARCH model, it is necessary to check the model adequacy by performing the diagnostic tests that involve serial correlation, normally distributed error and goodness of fit measures. All diagnostic tests are primarily carried on the standardized residuals via OLS and it is found that all are significant at 5% level. The diagnostic statistics with respect to EGARCH model are not reported here to conserve space. The results of Volatility spillover relationships between futures and spot market for sample commodities series using bivariate E-Garch model are reported in Table 7 and Table 8, panel A and panel B report results of indices and commodities respectively. The coefficient β_{sf} indicates the volatility spillover from futures to spot and β_{fs} means reverse direction. The coefficients β_{ss} and β_{ff} show the volatility clustering, while the coefficients λ_s and λ_f measure the degree of volatility persistence. The residuals of the model are tested for additional ARCH effects using ARCH LM test.

Volatility estimation is important for several reasons and for different people in the market pricing of securities if it is supposed to be dependent on the volatility of each asset. Market prices tend to exhibit periods of high and low volatility. This sort of behaviour is called volatility clustering. Volatility clustering is tested for all indices and commodities, which means "large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes," as noted by Mandelbrot (1963).

Table 7: Volatility Relationships - Dependent Variable - STDSPOT

Panel A: INDICES		Coefficient	Std. Error	z-Statistic	Prob.
COMDEX					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.02	0.14	-0.11	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	0.01	0.14	0.04	0.97
C. λ_f (volatility persistence)	LAGSTDSPOT	0.19	0.03	7.39	0
MCX-METAL INDEX					
A. B_{ff} (volatility clustering)	LAGSPOTEST	0.01	0.01	0.46	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.02	0.11	-0.21	0.83
C. λ_f (volatility persistence)	LAGSTDSPOT	0.84	0.02	44.94	0
MCX-ENERGY					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.16	0.13	-1.25	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.12	0.13	-0.92	0.36
C. λ_f (volatility persistence)	LAGSTDSPOT	0.09	0.03	3.25	0
Panel B: Commodities					
CHANA					
A. B_{ff} (volatility clustering)	LAGSPOTEST	0.09	0.05	1.72	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	0.08	0.05	1.54	0.12
C. λ_f (volatility persistence)	LAGSTDSPOT	0.47	0.03	16.54	0
GUARSEED					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.05	0.04	-1.18	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.04	0.04	-1.09	0.28
C. λ_f (volatility persistence)	LAGSTDSPOT	0.88	0.02	35.92	0
SOYBEAN					
A. B_{ff} (volatility clustering)	LAGSPOTEST	0.28	0.12	2.42	0.02
B. β_{fs} (volatility spillover)	LAGFUTUREEST	0.26	0.11	2.35	0.02
C. λ_f (volatility persistence)	LAGSTDSPOT	0.35	0.05	7.41	0
ZINC					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.93	0.24	-3.87	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.87	0.24	-3.58	0
C. λ_f (volatility persistence)	LAGSTDSPOT	0.01	0.03	0.18	0.86
LEAD					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.25	0.26	-0.95	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.27	0.27	-1.00	0.32
C. λ_f (volatility persistence)	LAGSTDSPOT	0.10	0.03	2.94	0
COPPER					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.25	0.26	-0.95	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.27	0.27	-1.00	0.32
C. λ_f (volatility persistence)	LAGSTDSPOT	0.10	0.03	2.94	0
NATURAL GAS					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.35	0.03	-10.90	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.31	0.03	-10.12	0
C. λ_f (volatility persistence)	LAGSTDSPOT	0.01	0.02	0.36	0.72
CRUDEOIL					
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.20	0.21	-0.94	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	-0.18	0.22	-0.84	0.4
C. λ_f (volatility persistence)	LAGSTDSPOT	0.08	0.02	3.09	0

The table describes volatility spillover (β_{sf} and β_{fs}) volatility persistence (λ_f and λ_s) and volatility clustering (β_{ff} and β_{ss}) from the spot to future or future to spot respectively. Volatility spillover is observed in 3 out of 8 commodities i.e. Soybean, Zinc and Natural Gas and none of the commodity indices. Volatility persistence is significant for both spot and future prices for all commodities and indices, the market-specific volatility clustering coefficients β_{ff} and β_{ss} are all positively significant at 5% level in the future and spot markets.

A quantitative manifestation of this fact is that, while returns themselves are uncorrelated, absolute returns |rt| or their squares display a positive, significant and slowly decaying autocorrelation function: corr (|rt|,|rt+τ |) > 0 for τ ranging from a few minutes to a several weeks. The market-specific volatility clustering coefficients β_{ff} and β_{ss} are all positively significant at 5% level in the future and spot markets. Of course, we can understand the efficiency degree in spot-futures market from one side according to the magnitude of correlative coefficients. Therefore, the Bivariate EGARCH model indicates that past innovations in futures significantly influence spot volatility, but the volatility spillovers from spot to futures are much weaker. Finally ARCH Lagrange Multiplier (LM) tests are used to test whether the standardized residuals of bivariate E-Garch model exhibit additional ARCH, see Table 9. Panels A and B report results of indcies and commodities respectively. The results reveal that EGARCH (1, 1) capture all the volatility dynamics.

Table 8: Volatility Relationship - Dependent Variable – STDFUTURE

Panel A: INDICES		Coefficient	Std. Error	z-Statistic	Prob.
COMDEX					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	0.01	0.14	0.09	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.01	0.14	-0.05	0.96
C. λ_f (volatility persistence)	LAGSTDFUTURE	0.19	0.03	7.41	0
MCX-METAL INDEX					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	0.85	0.02	46.18	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	0.00	0.00	0.61	0.55
C. λ_f (volatility persistence)	LAGSTDfuture	0.85	0.02	46.18	0
MCX-ENERGY					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.07	0.12	-0.59	0.01
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.10	0.12	-0.85	0.39
C. λ_f (volatility persistence)	LAGSTDfuture	0.09	0.03	3.26	0
Panel B: Commodities					
CHANA					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	0.07	0.06	1.23	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	0.08	0.06	1.38	0.17
C. λ_f (volatility persistence)	LAGSTD future	0.48	0.03	17.17	0
GUARSEED					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.04	0.04	-1.04	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.04	0.04	-1.14	0.25
C. λ_f (volatility persistence)	LAGSTD future	0.88	0.02	35.38	0
SOYBEAN					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	0.25	0.10	2.40	0.02
B. β_{fs} (volatility spillover)	LAGSPOTEST	0.28	0.11	2.48	0.01
C. λ_f (volatility persistence)	LAGSTD future	0.35	0.05	7.27	0
ZINC					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-1.13	0.25	-4.46	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-1.16	0.25	-4.70	0
C. λ_f (volatility persistence)	LAGSTD future	0.02	0.03	0.50	0.62
LEAD					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.26	0.27	-0.97	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.24	0.26	-0.91	0.36
C. λ_f (volatility persistence)	LAGSTD future	0.10	0.03	3.02	0
COPPER					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.26	0.27	-0.97	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.24	0.26	-0.91	0.36
C. λ_f (volatility persistence)	LAGSTD future	0.10	0.03	3.02	0
NATURAL GAS					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.19	0.03	-7.45	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.27	0.03	-10.72	0
C. λ_f (volatility persistence)	LAGSTD future	0.06	0.02	2.82	0
CRUDEOIL					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	-0.16	0.22	-0.74	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.18	0.22	-0.82	0.41
C. λ_f (volatility persistence)	LAGSTD future	0.08	0.02	3.20	0

The table describes volatility spillover (β_{sf} and β_{fs}) volatility persistence (λ_f and λ_s) and volatility clustering (β_{ff} and β_{ss}) from the spot to future or future to spot respectively. Volatility spillover is observed in 3 out of 8 commodities i.e. Soybean, Zinc and Natural Gas and none of the commodity indices. Volatility persistence is significant for both spot and future prices for all commodities and indices, the market-specific volatility clustering coefficients β_{ff} and β_{ss} are all positively significant at 5% level in the future and spot markets.

CONCLUDING COMMENTS

The literature relating to price discovery and volatility in commodity futures market has mainly been confined to developed economies. Though commodity markets in emerging economies like India have been growing exponentially, commodities and commodity derivatives are neither popular asset classes, nor have they been adequately researched. Empirical Studies on the subject show that the introduction of derivatives contracts improves the liquidity and reduces informational asymmetries in the market. The present study evaluates price discovery and volatility spillover effects in Indian commodities market to bridge the important gap in the literature.

Table 9: ARCHLM-Test

Panel A: Indices		Coefficient	Std. Error	t-statistic	Prob.
COMDEX					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.04	0.02	0	[0.23]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.05	0.02	2.15	[0.3]
METAL					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0	0.023	-0.1	[0.91]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0	0.023	0.34	[0.72]
ENERGY					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.01	0.02	0.57	[0.56]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.01	0.02	0.58	[0.56]
Panel B: Commodities					
CHANA					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.05	0.02	2.40	[0.21]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.06	0.02	2.44	[0.11]
GUARSEED					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.05	0.03	2.00	[0.14]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.04	0.02	1.57	[0.11]
SOYBEAN					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.01	0.04	0.38	[0.70]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.01	0.04	0.37	[0.70]
ZINC					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.00	0.02	0.15	[0.87]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.00	0.02	0.26	[0.79]
LEAD					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.03	0.02	1.11	[0.26]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.03	0.02	1.14	[0.25]
COPPER					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.08	0.02	3.57	[0.20]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.08	0.02	3.52	[0.20]
NATURAL GAS					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.06	0.02	2.29	[0.22]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.06	0.03	2.50	[0.11]
CRUDEOIL					
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.10	0.02	4.58	[0.23]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.04	0.02	1.90	[0.15]

The table shows ARCH LM Test which carries out a Lagrange multiplier tests to test whether the standardized residuals exhibit additional ARCH, with probability values in square brackets. The results show that EGARCH (1, 1) capture all the volatility dynamics.

We cover twelve commodities belonging to agriculture, metals and energy products as well as four commodity indices. The study period is from June 2003-march 2011. We find that spot and futures prices of all sample commodities and indices are non stationary, and in fact integrated of order one. A long run equilibrium relationship is confirmed for 8 out of 12 commodities and three out of four indices using Johansson cointegration procedure. These cointegration results are supported by VAR adequacy test. Short term dynamics in the spot and futures markets are examined using VECM. The results show that once the price relationship of spot and future markets deviates away from the long run coinetgrated equilibrium, both markets make adjustments to re-establish the equilibrium. In case of ten out of eleven commodities/indices, with an exception of Natural Gas error correction term of spot market is greater in magnitude than that of future market which implies that spot price makes greater adjustment in order to re-establish the equilibrium..The results of VEC Granger causality test show bi-directional Granger lead relationships between spot and futures in the MCX-Energy Index, Chana, Zinc, Lead, Copper, Crude oil and single Granger lead relationship from futures to spot in the Comdex Index. The Variance Decomposition results reconfirm the dominant role of futures in price discovery for these commodities and indices.

Next, we examine the volatility spillover effects for sample commodities and indices to verify whether any risk transfer mechanism can work between spot and futures market. E-GARCH results confirm bivariate volatility spillover for three commodities: Soybean, Zinc and Natural Gas with a stronger spillover from spot to futures market, thus efficient hedging as well as speculation strategies can be formed for theses commodities. No significant volatility spillovers are observed for the other commodities and indices. We conclude the Indian commodities market is still not perfectly competitive for some commodities. Overall, the price discovery results are encouraging given the nascent character of Indian commodity market. The results for Volatility Spillover are however weak thereby implying that the efficient risk transfer system is yet to evolve for most of the sample commodities.

The commodity market in India needs strong policy support owing to its relevance in the macro economy with implications for price inflation, economic growth and employment. Hence there is an urgent need for policy makers to support these trading platforms with infrastructure development, fiscal incentives, encouraging product innovation, widening investor base and investor education so that they are able to realise their true potential. Consequently, the institution of manager (or investor) should understand the futures markets clearly and supervise (or invest) properly to ensure the efficiency of futures market. More importantly, the international pricing authority in Indian futures markets should be improved as quickly as possible in order to maintain economic security. The present research contributes to alternative investment literature for emerging markets. Future research on comparative analysis of emerging economies can grasp the true picture of improvements that are needed to capture the gains of derivative market in India which is outside the scope of present study.

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