Price Discovery and Volatility Spillovers in Futures and Spot Commodity Markets: Some Empirical Evidence from India

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Price discovery and volatility spillovers in futures and spot commodity markets: Some empirical evidence from India

Mantu Kumar Mahalik[1], Debashis Acharya[2] and Suresh Babu M[3]

Abstract: *Indian commodity futures markets registered 373% growth during 2005-06. Despite this growth rate, there is skepticism about the effect of commodity futures on its underlying assets in India. In this context, the present study examines price discovery and volatility spillovers in Indian spot-futures commodity markets by using cointegration (Johansen, 1991), VECM and the bivariate EGARCH (Nelson, 1991) model. This study has used four futures and spot indices of Multi-Commodity Exchange (MCX), Mumbai that employes daily data spanning over 12th June 2005 to 31st December 2008. The Vector Error Correction model shows that commodity futures markets like natural logarithim of agriculture future price index (LAGRIFP), energy future price index (LENERGYFP), and aggregate commodity index (LCOMDEXFP) effectively serves the price discovery function in the spot market implying that there is a flow of information from future to spot commodity markets but the reverse causality does not exist while there is no cointegrating relationship between metal future price index (LMETALFP) and metal spot price index (LMETALSP). Besides the bivariate GARCH model indicates that although the innovations in one market can predict the volatility in another market, the volatility spillovers from future to the spot market are dominant in the case of LENERGY and LCOMDEX index while LAGRISP acts as a source of volatility towards the agri-futures market.*

Key Words: Price discovery, volatility spillovers, Cointegration and ECM

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1. Introduction

Commodities are regarded as separate assets in the domain of all assets class. It is perceived that commodity markets are volatile. Therefore, the price volatility drives the demand for hedging the risk in the commodity market. Producers and consumers often seek ways of hedging risk and trading risk. In response to this need, derivative markets for commodity risks trading arose, and their use has become increasingly widespread. Instruments traded in these markets include 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. A futures contract is also an agreement to deliver a specified quantity of commodity at a specified future date, at a price (the future price) to be paid at the time of delivery. Futures contracts are usually traded on organized exchanges and tend to be more liquid than the forward contract. Other than this, a futures contract differs from a forward contract only in that the futures contract is 'marked to market', which means that there is settlement and corresponding transfer of funds at the end of each trading day. Future market performs several economic functions that include hedging function, price discovery function, financing function, liquidity function and price stabilization.

Commodity futures trading existed in India since 1875. However the commodity futures have been in the state of hibernation for the past few decades owing to a lot of government restrictions. Significant developments took place in 2003-04 in terms of commodity futures market. The government issued a notification on April 1, 2003 withdrawing all previous notifications which prohibited futures trading in a large number of commodities in the country. This was followed by a notification in May 2003 revoking prohibition on non-transferable specific delivery forward contracts. The futures market was opened in anticipation of sound market institutions and market design. In order to set up proper markets, the Government of India (GOI) on recommendation of Forward Market Commission (FMC) granted recognition to National Multi Commodity Exchange, Ahmedabad (NMCE); Multi Commodity Exchange, Mumbai (MCX); National

Commodity and Derivative Exchange, Mumbai (NCDEX) as nationwide multi commodity exchanges. Trading commenced at MCX in November 2003 and at NCDEX in December 2003. The FMC applied high standards to the market design. All the three exchanges were required to ensure anonymous order-matching. Prior to these exchanges trading typically took place in small groups who knew each other. But new exchanges offered electronic clearance scheme. The centralized nature of electronic system would overcome difficulties of fragmented and non-transparent price discovery. The FMC also drew upon the learning of equity markets in terms of favouring the demutualised governance structure for the new exchanges. Setting up futures markets was not simple owing to the fact that there is no properly developed spot market. The spot market is fragmented geographically spread across the country. NCDEX for example had to introduce a polling mechanism for spot prices from across mandis. Every commodity had a different set of mandis to be polled depending upon the proportion of spot market trade. The total volume of trade in the commodity future market rose from Rs. 34.84 lakh crore in 2006 to Rs. 36.54 crore in 2007. The volume growth in trade is primarily propelled by MCX and NCDEX. These exchanges also account for a large number of futures contract traded.

Under 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). However, 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. Futures markets given their inherent leverage, low transaction costs, and lack of short sale restrictions (Tse, 1999). Risk transfer and price discovery are two of the major contributions of future markets to the organization of economic activity (Working, 1962 and Garbade and Silber, 1983). Risk transfer refers to hedgers using futures contracts to shift price risk to others. Price discovery refers to the use of future prices for pricing cash market transactions or price discovery means that futures price serves as market's expectations of subsequent spot price (Garbade and Silber, 1983). In other words, price discovery is the process by which markets incorporate this information to arrive at equilibrium (Working, 1948). In a static sense, price discovery implies the existence of equilibrium price and in a dynamic sense, the price discovery process describes how information is produced and transmitted across the markets. In addition, it also impounds information to all the market participants. Price discovery is a major function of commodity future market. Information on price discovery is essential since these markets are widely used by firms engaged in the production, marketing and processing of the commodities. The essence of the discovery function of future markets hinges on whether new information is reflected first in changed futures prices or in changed cash price (Hoffman, 1931). It is conventionally claimed that futures market tends to be the dominant points of price discovery than that spot market.

Several studies suggest that futures markets play a critical role in price discovery for the underlying spot market (Lien and Tse, 2000). This price discovery function implies prices in the futures and spot markets are systematically related in the short run and/or in the long run. In the cointegration framework, the price discovery function implies the presence of an equilibrium relation binding the two prices together. If a departure from equilibrium occurs, prices in one or both markets should adjust to correct the disparity.

There is a consensus on price discovery issue in any purely competitive market. In a purely competitive market, price discovery issue is more important for all economic agents like producers, wholesalers, and other agents. Because all agents are operating in the product market and also taking decisions for their products irrespective of buyers or sellers on the basis of market price behaviour . Ultimately, better decision making leads to an optimal allocation of scarce resources (Manfredo and Sanders, 2007). The rest of the paper is organized into the four sections. The second section highlights both theoretical and empirical literature. Section 3 presents methodology and data. The last section summarizes the empirical results and findings.

2. Literature Review

The present section outlines both theoretical as well as empirical literature on price discovery and volatility spillovers in the spot-futures markets in the International and Indian context. The review of the earlier studies here is attempted chronologically in order to get a comprehensive picture.

Booth, Martikeinan and Tse (1997) examined the price and volatility spillovers in the context of four Scandavian stock markets including Danish, Norwegian, Swedish, and Finnish stock markets for the period 2 May 1988 to 30 June 1994 by employing the multivariate EGARCH model. They found that volatility transmission was asymmetric, spillovers being more pronounced for bad than good news. Significant price and volatility spillovers exist but they are few in number.

Thomas and Karande (2001) analyzed price discovery in India's custorseed market, Ahemedabad and Bombay by using daily closing data on future and spot prices, which spans from May 1985 to December 1999. Although, they have employed G.S. model and seemingly unrelated regression approach, but the interpreted relationship between spot and future markets remained the same in both the estimation approaches. Besides estimating GS return equation separately for the respective months like March, June, September and December, the study ultimately estimated pooled data in merging four contracts. They found that out of four, three seasonal contracts in Bombay future prices lead the Ahemedabad future prices while the March contract in Ahemedabad future prices lead the former one. Despite having smaller volume, the Bombay dominants the future prices over the Ahemedabad prices for all contracts except the contracts maturing at the time of harvest. The reason is due to the fact that prices of caster seeds are largely driven by the export demand. Since the traders or exporters expose to the port in Bombay, the markets have a lead in getting information that drives prices in the June, September and December contracts. This study shows that markets that trade exactly the same asset, in the same time zone, do react differently to information and also small market may lead the large market.

Mooosa (2002) re-examined the Garbade and Silber (1983) model with the objectives of finding out if the crude oil future market perform the function of price discovery and risk transfer. The study uses the daily data of spot and one-month future prices of WTI crude oil covering from 2 January 1985 to July 1996. He found that sixty percent of the price discovery function is performed in future market. The result also showed a fairly elastic supply of arbitrage service. This study shows that Garbade and Silber model is more suitable for description of intraday behaviour of spot and future prices.

Kumar and Sunil (2004) investigated the price discovery in six Indian commodity exchanges for five commodities. For their study they have used the daily futures and comparable ready price and also engaged the ratio of standard deviations of spot and future rates for empirical testing of ability of futures markets to incorporate information efficiently. Besides, the study has empirically analyzed the efficiency of spot and future markets by employing the Johansen cointegration technique. They found that inability of future market to fully incorporate information and confirmed inefficiency of future market. However, the authors concluded that the Indian agricultural commodities future markets are not yet mature and efficient.

Zhong et al. (2004) investigated the hypotheses that the recently established Mexican stock index futures markets effectively served the price discovery function, and that the introduction of futures trading led to volatility in the underlying spot market using a total of 799 daily observations which covers the period 15 April 1999 to 24 July 2002. By using VECM and EGARCH models, the empirical evidence showed that the futures price index was a useful price discovery vehicle and future trading had also been a source of instability for the spot market.

The study by Zapata, Fortenbery and Armstrong (2005) examined the relationship between 11 future prices traded in New York and the World cash prices for exported sugar by considering the observation from January 1990 to January 1995. They found that the future market for sugar leads the cash market in price discovery. However, they also found unidirectional causality from future price to spot but not vice versa. The finding of cointegration between futures and cash prices suggests that sugar future contract is a useful vehicle for reducing overall market price risk faced by cash market participants selling at the world price. Further it was found through impulse response function that a one unit shock in the future price innovation generates a quick (one month) and positive response in futures and cash prices, but not vice versa.

Fu and Qing (2006) examined the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen cointegration, VECM and bivariate EGARCH model. The empirical results indicated that the models provided evidence to support the long-term equilibrium relationships and significant bidirectional information flows between spot and futures markets in China, with futures being dominant. Although innovations in one market could predict the futures volatility in another market, the volatility spillovers from futures to spot were more significant than the other way round.

Gupta and Belwinder (2006) examined the price discovery mechanism in the NSE spot and future market. The study uses the daily closing values of index future SandP CNX Nifty, from June 2002 to February 2005. By using the techniques like Johansen and VECM, it was empirically found that there was bilateral causality between the Nifty index and futures. Besides, it was also found that there exists stronger casual relation from Nifty futures to Nifty index as compared to the vice-versa. This might be the reason due to the lower cost of transactory in the future market and future market provides flexibility to investors i.e., investors enable to speculate on the price movement of the underlying asset without the financial burden of owning asset themselves.

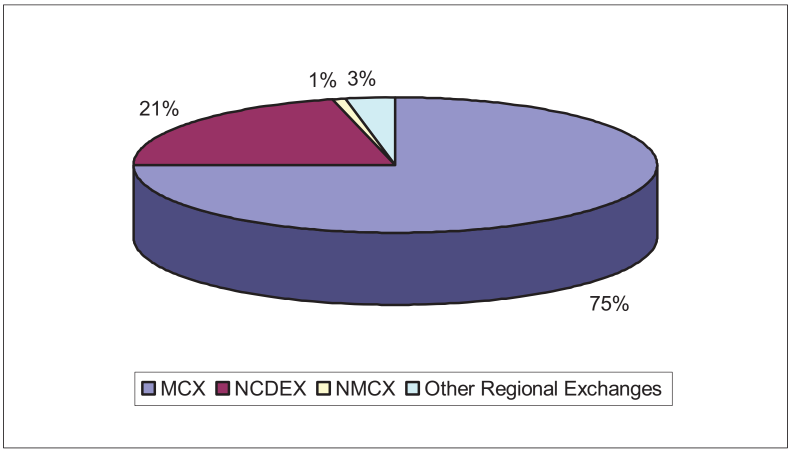
Praveen and Sudhakara (2006) attempted to study a comparison of price discovery between stock market and the commodity future market. They have taken Nifty future traded on National Stock Exchange (NSE) and gold future on Multi Commodity of India (MCX). The result empirically showed that the one month Nifty future did not have any influence on the spot Nifty, but influenced by future Nifty itself. The casual relationship test in the commodity market showed that gold future price influenced the spot gold price, but not the contrary. So this implies that information is first disseminated in the future market and then later reflected in the spot market. Their study on spot prices of gold during the period of April 2002 to June 2005 showed that the Indian gold prices volatility is relatively higher than global market and Indian stock market has declined during their study period. It was found that the stock market has well developed spot market due to its presence of national wide stock exchange, which provides the stock market a perfect platform for price discovery while the spot commodity market is far away from this platform because spot gold is not confined to one place.

Given the above background, it is apparent that mostly research on the price discovery role of futures markets and their possible volatility implications for the spot market generally focused on the US and a few other developed markets. This paper examines the case for India that has recently established the commodity futures trading. At least two main features distinguish our analysis in this paper i.e., the futures market effectively serves the price discovery function, and that the introduction of futures trading has resulted volatility in the underlying spot market.

3. Methodology and Data

The preface of new information results in price discovery for short intervals of time between futures and spot market due to communication cost. Both 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). However, the price linkage between futures market and spot market would be examined by using cointegration (Johansen, 1991) analysis that has several advantages. First, cointegartion analysis reveals the extent to which two markets have moved together towards long run equilibrium. Secondly, it allows for divergence of respective markets from long-run equilibrium in the short run. Besides, the cointegrating vectors identify the existence of long run equilibrium while error correction dynamics describe the price discovery process that helps the markets to achieve equilibrium (Schreiber and Schwartz, 1986).

To examine the cointegrating and error correction dynamics, this study used four futures indices and corresponding underlying spot indices of Multi-Commodity Exchange (MCX), Mumbai. The four indices are MCXCOMDEX, MCXAGRI, MCXENERGY, and MCXMETAL. The study has used natural logarithm for the transformation of daily data as well as to minimize the heteroscedasity in the value of the level series i.e., LAGRIFP & LAGRISP, LENERGYFP & LENERGYSP, LMETALFP & LMETALSP and LCOMDEXFP & LCOMDEXSP. The period of study is from June 2005 to December 2008 after adjusting for dates and missing observations caused by holidays, the total observations for LAGRI index are 1047 and 1049 followed by rest three indices like LENERGY, LMETAL and LCOMDEX index. The market share is a main source of the motivation for considering MCX rather than NCDEX in the analysis. The Indian commodity exchanges market share in terms of total turnover (End-December, 2007) is shown below.



Note: Economy Survey 2007-08, Government of India

Cointegrating methodology fundamentally proceeds with non-stationary nature of level series and minimizes the discrepancy that arises from the deviation of long-run equilibrium. The arrived 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 cointegrated, 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 a linear combinations of both the level series canceling the stochastic trend, thereby producing a stationary series. 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, coinetgration analysis delivers the message saying how two markets (such as futures and spot commodity markets) reveal pricing information that are identified through the price difference between the respective markets. The implication of cointegration is that both 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 well 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 change in one market (futures or spot commodity market) generating price change in the other market (spot or commodity futures) with a view to bring a long run equilibrium relation is :

$$F_t = \alpha + \beta S_t + \varepsilon_t \qquad (1)$$

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

$$F_t - \alpha - \beta S_t = \hat{\varepsilon}_t \qquad (2)$$

Where F_t and S_t are futures and spot price of some commodities in the respective markets at time t. Both α and β are intercept and coefficient terms, where as $\hat{\varepsilon}_t$ is estimated white noise disturbance term. The main advantage of coinetgartion 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:

$$\Delta F_t = \delta_f + \alpha_f \hat{\varepsilon}_{t-1} + \beta_f \Delta F_{t-1} + \gamma_f \Delta S_{t-1} + \varepsilon_{f,t} \quad (3)$$

$$\Delta S_t = \delta_s + \alpha_s \hat{\varepsilon}_{t-1} + \beta_f \Delta S_{t-1} + \gamma_f \Delta F_{t-1} + \varepsilon_{s,t} \quad (4)$$

In the above two equations, the first part ($\hat{\varepsilon}_{t-1}$) 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, are 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 an 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 the price discovery process.

Bivariate EGARCH Model and Volatility Spillover

This section hypothesizes the volatility spillovers. The volatility spillovers reveal that future trading could intensify volatility in the underlying spot market, perhaps 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) generalized autoregressive conditional heteroscedastic (GARCH) model can not 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 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 some weakness of the EGARCH 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 (Bollerslev) to be estimated. The need for this approach, as opposed to the now common GARCH specification, is explained by Bae and Karolyi (1994) and Koutmos and Booth (1995), who collectively report that the volatility transmission between U.S., U.K. and Japanese stock markets is asymmetric. Moreover, the EGARCH model allows negative shocks to behave differently than the positive shocks. In this study, the estimation process is not concentrated about the return series but about the direct spillover between futures and spot markets for MCX in Indian commodity market.

The study uses the bivariate EGARCH (1, 1) model to examine the volatility spillover mechanism. More specifically, the conditional mean equation is specified in the autoregressive process of order r:

$$P_t = \alpha_0 + \sum_{i=1}^{r} a_i P_{t-1} \qquad (5)$$

Where $\varepsilon = \begin{pmatrix} \varepsilon_{f,t} \\ \varepsilon_{s,t} \end{pmatrix} / \psi_{t-1} \sim N(0, \Omega_t), \Omega_t = \{\rho_{ij}, \sigma_{i,t}, \sigma_{j,t}\}$

$$\log(\delta_t^2) = E\left\{\alpha_0 + \sum_{i=1}^{q} \alpha_i g(z_{t-i})\right\} + \sum_{i=1}^{p} \beta_i \log(\sigma_{t-1}^2) \qquad (6)$$

$$g(z_t) = \theta z_t + [|z_t| - E|z_t|] \qquad (7)$$

$$\ln(\sigma_t^2) = \alpha_0 + \alpha_1 \left(\varepsilon_{t-1} / \sigma_{t-1}^{0.5} \right) + \lambda_1 \left| \varepsilon_{t-1} / \sigma_{t-1}^{0.5} \right| + \beta_1 \ln(\sigma_{t-1}^2) \qquad (8)$$

Where, ε_t is the stochastic error term or innovation, ψ_{t-1} is the information set at time t-1, σ_t^2 is the conditional (time-varying) variance, and z_t is the standardized residual$\left(\frac{\varepsilon_t}{\sigma_t}\right)$. Conditional ε_t is assumed to be normally distributed with zero mean and constant variance. The autocorrelation and partial autocorrelation functions are considered and residuals from the mean equations are tested for white noise using the Ljung-Box statistics to determine the lag length r, for each price index series. Two lags were found to be optimal for each index series to yield uncorrelated residuals for the time period considered (Jun 2005 through December 2008).

Equation (6), the conditional variance equation reflects the EGARCH (p, q) representation. According to EGARCH model, the variance is conditional on its own past values as well as function of z_t, or the standardized residuals$\left(\frac{\varepsilon_t}{\sigma_t}\right)$. We are also typically concerned about potential size and persistence of shocks, which is an indicator of market efficiency. The persistence of volatility implied by equation (6) is measured, if the unconditional variance is finite i.e.,$\sum_{i=1}^{p} \beta_i < 1$ in absolute value. The smaller the absolute value of this sum, the less persistent volatility is after a shock. In the equation (7), the right hand sight captures the ARCH effect. It contains the two parameters which define the 'size effect' and the 'sign effect' of the shocks on volatility. The first is a typical ARCH effect while the second is an asymmetrical effect, for example, the leverage effect.

In equation (8), the EGARCH model allows for leverage effects. If $\varepsilon_{t-1}/\sigma_{t-1}^{0.5}$ is positive, the effect of shock on the log of conditional variance is $\alpha_1+\lambda_1$. If $\varepsilon_{t-1}/\sigma_{t-1}^{0.5}$ is negative, the effect of shock on the log of conditional variance is $-\alpha_1+\lambda_1$.

Now, we can represent the bivariate EGARCH (1, 1) model as follows:

$$\ln\left(\sigma_{f,t}^2\right)=\sigma_f+\omega_f\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}-\sqrt{\frac{2}{\pi}}\right|+\gamma_f\ln\frac{\varepsilon_{t-1}}{\sigma_{t-1}}+\alpha_f\ln\left(\sigma_{2,t-1}^2\right)+\nu_f\ln\left(\varepsilon_{s,t-1}^2\right) \qquad (9)$$

$$\ln\left(\sigma_{s,t}^2\right)=\sigma_s+\omega_s\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}-\sqrt{\frac{2}{\pi}}\right|+\gamma_s\ln\frac{\varepsilon_{t-1}}{\sigma_{t-1}}+\alpha_s\ln\left(\sigma_{2,t-1}^2\right)+\nu_s\ln\left(\varepsilon_{s,t-1}^2\right) \qquad (10)$$

The unrelated residuals $\varepsilon_{f,\mathrm{t}} and\, \varepsilon_{s,t}$ 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). Estimating these two models simultaneously in one step is not practical because of the large number of parameters involved. Moreover, although the paper focuses more on volatility spillovers (second moment) than coinetgration (first moment), the error correction term must be included in the conditional mean equation. Otherwise, the model will be misspecified and the residuals obtained in the first step (and, consequently, the volatility spillovers results) will be biased.

4. Empirical results and discussions

The empirical analysis reported here is based on two-stage estimation. In the first stage, cointegration analysis is used to identify the cointegrating relationship among the variables. If cointegrating relationship is identified, the model should include residuals from the vectors (lagged one period) in the dynamic Vector Error Model (VECM) system.

Before we test for cointegrating in MCX commodity indices, it is necessary to check the order of integration of the level variables. Therefore, unit root tests of each variable at their levels as well as first differences of non-stationary level variables were conducted.[4] The result from Table 1 shows that all the variables are non-stationary at their levels. However, all the non-stationary variables are found to be stationary at their first differences, and therefore, are integrated of order one (i.e. I(1)) in MCX commodity future markets.

Table 1: Results of ADF and PP Tests for Unit Root

Variables	Levels		Ist differences		Inference on integration
	ADF	PP	ADF	PP	
LAGRISP	-1.974^{T} (3)	-1.953^{N} (4)	-30.821^{N} (1)	-30.852^{N} (4)	I(1)
LAGRIFP	-1.976^{C} (3)	-1.961^{C} (4)	-30.158^{C} (1)	-30.165^{N} (1)	I(1)
LENERGYSP	-0.231^{T} (2)	-1.725^{C} (1)	-29.246^{N} (3)	-45.694^{N} (1)	I(1)
LENERGYFP	-1.080^{C} (3)	-0.230^{N} (3)	$-23.\ 450^{N}$ (4)	-47.904^{C} (1)	I(1)
LMETALSP	-2.133^{C} (1)	-2.130^{C} (1)	-33.598^{N} (1)	-33.750^{T} (3)	I(1)
LMETALFP	-1.680^{C} (1)	-1.715^{C} (5)	-28.378^{T} (6)	-44.657^{N} (3)	I(1)
LCOMDEXSP	0.368^{T} (4)	-1.458^{C} (2)	-29.502^{N} (3)	-29.531^{N} (3)	I(1)
LCOMDEXFP	0.200^{N} (4)	-1.716^{C} (6)	-28.336^{T} (3)	-44.451^{C} (8)	I(1)

Note: L stands for natural logarithm of the respective variables, the parentheses shows the lag length and the optimal lag length for the ADF and PP tests is based on the AIC and SBC criteria. The McKinnon critical values for ADF and PP tests at 1%, 5% and 10% are -3.60, -2.93 and -2.60 respectively for without trend but intercept (denoted by superscript C) and -4.20, -3.52 and -3.19 respectively for with trend and intercept (denoted by superscript T) and -2.61, -1.94 and -1.61 respectively for no trend and intercept (denoted by N). For PP tests at 1%, 5%, and 10% are -3.69, -2.97 and -2.62 respectively for without trend but intercept (denoted by superscript C) and -4.33, -3.58 and -3.22 respectively for with trend and intercept (denoted by superscript T) and -2.65, -1.95, and -1.62 respectively for no trend and intercept (denoted by N).

The results of Cointegration-Vector Error Correction Model

The conformation that each level series is I(1) allowed us to proceed to Johansen cointegrating test with respect to each individual index price series for spot and future markets. Johansen's cointegration test is more sensitive to the lag length employed. Besides, inappropriate lag length may give rise to problems of either over

[4] Refer to the Gujarati, D.N. et al., (2003) and Ender, W. et al., (2004) for unit roots analysis.

parameterization or underparametrisation. As we know, in the error correction equation, all non-stationary variables are treated as endogenous, the constant, and an error correction term being exogenous variables. The objective of the estimation is to ensure that there is no serial correlation in the residuals. Here, Akaike information criterion (AIC) and Schwarz information criterion (SIC) are used to select the optimal lag length. According to AIC and SIC criterion, the optimal lag length for LAGRI index is one, three for LENERGY index and two for LCOMDEX index respectively.

Cointegration Test Results

Cointegrating relationship is tested with the equation (1). The relationship is estimated by the Johansen cointegration test. The Table 2 presents the trace and maximum eigenvalue statistics for the sample period: 06/08/2005 to 12/30/2008. The test statistics are significant at 5% level which is common for every index. Both the tests reject the null hypothesis of no cointegration ($r = 0$) at the 5% level, where as they do not reject the alternative hypothesis that $r \leq 1$. This suggests there exists two cointegrating vectors in the case of LAGRI index, one cointegrating vectors followed by LENERGY and LCOMDEX index. Therefore, the conclusion is that $r \geq 1$, that is, there is more than one stationary relationship among the variables. Now, the empirical evidence is clear evident for cointegrated relationship in MCX spot and future commodity markets. That means there is price discovery process in the spot and future commodity markets.

Table 2: Johansen's Cointegration Rank Test

Commodities	Hypothesis		t-statistics	
	Null hypothesis	Alternative hypothesis	$\lambda trace$	$\lambda \max$
LAGRISP & LAGRIFP	$r = 0$	$r \geq 1$	15.82468*	16.27841*
	$r \leq 1$	$r \geq 2$	4.54627*	4.54627*
LENERGYSP & LENERGYFP	$r = 0$	$r \geq 1$	122.1890*	121.2666*
	$r \leq 1$	$r \geq 2$	0.92239	0.92239
LCOMDEXSP & LCOMDEXFP	$r = 0$	$r \geq 1$	64.81547*	62.45753*
	$r \leq 1$	$r \geq 2$	2.35794	2.35794

Note: The asterisk (*) shows significant at 5 % level.

Despite determining the number of cointegrating vectors for each commodity index, it is customary to produce the diagnostic checking criterions before estimating the ECM model. The results reported in Table 3 points out that VAR estimated with various lags like 1, 2 and 3 satisfies the stability, normality test as well as no serial correlations among the variables in the VAR model. Therefore, it leads us to take the position that our model fulfills the model adequacy tests for the analysis.

Table 3: Diagnostic Checking Criterions

Commodities Index	Adequacy test for VAR model	Critical values	lags
LAGRIFP & LAGRISP	Stability (modulus values of roots of characteristics polynomials	0.99, 0.94	1*
	Normality Chi-Square values	455.6840	1*
	Serial Correlation LM-Test	185214.21	1*
LENERGYFP & LENERGYSP	Stability (modulus values of roots of characteristics polynomials	0.99, 0.50, 0.30, 0.25	2*
	Normality Chi-Square values	10051.04, 12541.07	2*
	Serial Correlation LM-Test	20.94, 39.44	2*
LCOMDEXFP & LCOMDEXSP	Stability (modulus values of roots of characteristics polynomials	0.99, 0.83, 0.44, 0.20, 0.11	3*
	Normality Chi-Square values	232.73, 111692.35	3*
	Serial Correlation LM-Test	24.58, 45.92, 50.59	3*

Note: The asterisk (*) shows significant at 1, 2 and 3 lags.

The result reported in the Table 4 shows α is the speed of adjustment coefficient of loading factor in the ECM model. The ECM result indicates that there is a one way strong causality from future commodity market to the spot market but the reverse feed back does not exist. Broadly, the element of the vectors indicates that each market adjusts to the new equilibrium price following a price discrepancy, that means the future market possesses the dominance quality over the spot market and also serve the effective price discovery since the α coefficient of future market is higher than α coefficient of spot market. This implies future market has the capability to expose the all new information through the channel of its new innovation and then spillovers certain information to the spot market in the case of all commodity indices in MCX.

Table 4: ECM Statistics for AGRI, ENERGY and COMDEX

	LAGRI		LENERGY		LCOMDEX	
	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t
$\Delta\delta_{i,}\ i = S\,F$	-3.43E-05 [-0.17358]	-0.00016 [-0.57880]	0.00026 [0.27388]	0.00022 [0.23447]	0.00011 [0.23032]	-1.77E-05 [-0.05343]
ΔF_{t-1}	0.105824 [4.13514]	-0.00467 [-0.12377]	0.224096 [5.84675]	0.02108 [0.55404]	-0.28912 [-6.26816]	0.25995 [8.57375]
ΔF_{t-2}			0.05670 [1.76148]	0.014058 [0.43973]	-0.15011 [-3.22597]	0.182554 [5.96814]
ΔF_{t-3}					-0.04413 [-1.13681]	0.09116 [3.57258]
ΔS_{t-1}	-0.519039 [-22.9939]	-0.04940 [-1.49408]	0.005848 [0.14086]	0.29362 [7.12156]	0.22034 [3.73367]	-0.10141 [-2.61427]
ΔS_{t-2}			-0.051185 [-1.47532]	0.108304 [3.14353]	0.06875 [1.23365]	-0.07761 [-2.11870]
ΔS_{t-3}					0.011184 [0.23852]	-0.03240 [-1.05134]
$\Delta\alpha_{i,}\ i = SF$	0.019948 [2.98592]	-0.00495 [-0.50339]	0.337953 [9.04801]	-0.22180 [-5.98005]	0.19820 [4.99544]	-0.07296 [-2.79773]

Note: [] shows t statistics

The above empirical findings reveal that the future commodity markets like LAGRIFP, LENERGYFP and LCOMDEXFP play a dominant role and serve effective price discovery in the spot commodity market but the reverse causality does not exist while metal commodity spot-future markets (LMETALFP & LMETALSP) are not taken into consideration as there is no cointegrating relationship between them. Thus, no inference can be drawn with respect to the metal spot-future commodity markets. This may be due to the fact that future commodity markets are more innovative that enables them to expose the all available new information with respect to the price of the commodities and investors' behaviour in the market. This implies all the investors are able to realize their expected future price of the spot commodity price due to the efficiency of the future market. The question that can be raised here: why is there no causality from spot to the future markets? This issue throws a challenge before the policy makers in India to target it.

The Empirical Results on Volatility Spillovers

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 1% level.[5]

Table 5: Empirical Results of Volatility Spillovers

	COMMODITIES INDEX					
	LAGRI		LENERGY		LCOMDEX	
	Future	Spot	Future	Spot	Future	Spot
σ_i	-11.23848* (-14.2439)	-14.09037* (-20.2961)	-0.981209* (-5.7860)	-12.83448* (-164.4902)	-0.013046 (-0.5097)	-1.248387* (-8.3377)
ω_i	-0.116604* (-3.3687)	0.118295* (2.6483)	0.508185* (12.0187)	-0.048295* (-5.8889)	0.049586* (3.4484)	0.526973* (11.8149)
γ_i	-0.042137 (-1.4148)	-0.265202* (-6.8077)	0.213721* (6.0594)	-0.336371* (-40.8185)	0.024148* (2.6789)	-0.177054* (-5.2619)
α_i	-0.095239 (-1.2362)	-0.491430* (-6.4855)	0.908474* (42.1807)	-0.793660* (-85.0683)	1.002450* (424.7825)	0.895548* (55.1043)
ν_i	22.79984* (31.4799)	15.87027* (2.7049)	5.016231* (4.7490)	2.500697* (5.5013)	1.379039** (2.2679)	2.745596 (0.7227)

Note: The parenthesis shows the z statistics and the asterisk * (**) reveals significant at 1% and 5% levels.

[5] The diagnostic statistics with respect to EGARCH model are not reported here to conserve space; it can be made available upon request.

In the above EGARCH (1, 1) result, the coefficients of $v_s and v_f$ are very important and reveal volatility spillover from the spot to future or future to spot. The results obtained from the Table 5 supports the price discovery result to some extent, volatility spillover from future to spot except in the case of LAGRI index where volatility spillover from spot to future. In the above table, the corresponding coefficients are significant except LCOMDEXSP. The study claims that volatility spillover exists from future to spot because v_s is larger than the v_f in any future market but the reverse exists in the case of LAGRI index. Hence, the future market plays a vital role especially in the case of effective price discovery. But the LAGRISP market also acts as a source of volatility for the future market. However, the bivariate EGARCH model indicates that past innovation in future significantly influence spot volatility, except in the case of LAGRI volatility spillover from spot to future.

In an arbitrage free economy, price volatility is directly related to the flow of information. If future market increases the flow of information through the development of new technology, then the spot commodity market exposes the degree of volatility from the future market. The very implication of this model is that the volatility of asset price in market will rise due to the conditionality of increasing flow of information, thereby, generating the volatility in the spot market. The findings of this study support this theory, except in the case of LAGRI commodity index. The reasons may be due to the fact that the agricultural farmers are not dealing with the futures market that involves huge uncertainty backed by the high risk. This shows the nature of commodity market is quite backward in terms of lack of incentives and low quality of technology available to the farmers. This, in turn, discourages the agricultural farmers to keep the large size of holdings for the production. That means they are only interested in the subsistence production which is sufficient for them. Despite the lack of incentive, they acquire more land holdings and produced more that will not give more competitive advantage in the future international market due to increasing costs of production, backed by the low quality of technology. Besides, farmers in the spot market are not relying on the futures market on account of unjustifiable rising prices that is generated by speculators. From the policy perspective, the price discovery and volatility spillover are important as it helps them to formulate the function of the policy and also the present study necessitates the government intervention to check the dynamics of both spot and future commodity markets in India.

Conclusion

The above empirical findings reveal that the future commodity markets like LAGRIFP, LENERGYFP and LCOMDEXFP play a dominant role and serve effective price discovery in the spot commodity market but the reverse causality does not exist while metal commodity spot-future markets (LMETALFP & LMETALSP) are not taken into consideration as there is no coinetgrating relationship between them. Thus, no inference can be drawn with respect to the metal spot-commodity markets. This may be due to the fact that future commodity markets are more innovative that enables them to expose the all available information with respect to the price of the commodities and investors' bevaviour in the market. This implies all the investors are able to realize their expected future price of the spot commodity price due to the efficiency of the future market. The question that can be raised here: why is there no causality from spot to the future markets? This issue makes a challenge before the policy makers in India to target it.

The study claims that volatility spillover exist from future to spot because ν_s is larger than the ν_f in any future market but the reverse exists in the case of LAGRI index. Hence, the future market plays a vital role especially in the case of effective price discovery. But the LAGRISP market also acts as a source of volatility for the future market. However, the bivariate EGARCH model indicates that past innovation in future significantly influence spot volatility, except in the case of LAGRI volatility spillover from spot to future. From the policy perspective, the price discovery and volatility spillover are important as it helps them to formulate policy and also the present study calls for government intervention to check the dynamics of both spot and future commodity markets in India.

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