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# A Study of the Causality and Lead-Lag Relationships in the MCX Spot & Future Indices

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**Abstract**
This paper aims to investigate the causal relationships and lead-lag behaviors in the Indian Commodities market, by the use of econometric techniques. The study aims to apply the Vector Error Correction Model (VECM) to identify the lead-lag relationships, direction and speed of adjustments in the Indian commodities market. The findings of this study suggest that, in the long run, the spot markets lead the futures in most of the commodity segments, while there is a causal relationship from futures to spot also in the case of Energy segment alone. It also finds out the extent to which the futures markets adjust in order to reach the equilibrium in the long run. This study can be helpful when deciding policy changes, regulatory frameworks, and investment and portfolio decisions.
**Keywords:** Lead-Lag behavior, Causality, Price Discovery, Cointegration

## Introduction

It is well known that the commodity prices are highly dependent on the global supply and demand conditions for that commodity. But apart from these fundamental factors, the popular belief is that futures trading and the futures markets have led to increased speculative activity by the market participants and thus drives the prices haywire, thus increasing the volatility in the underlying spot markets. But on the other hand efficient information flow and price discovery is also sometimes attributed to the futures market and introduction of futures trading. Financial investors provide the necessary liquidity in the commodity markets.

Related theory suggests that the spot and futures markets are related by the „cost of carry", which is nothing but the costs involved in buying and holding a commodity in advance rather than buying a futures contract for delivery in the future. It is this cost which eliminates arbitrage opportunities and till this relationship hold good, there is always a chance that any increase in the futures market volatility could lead to increased volatility in the spot market. However on the flipside of this relationship, the condition where supply and demand factors underpin the spot price can also arise. In that case, the futures price will not be able to deviate too far away from this equilibrium fundamental price in the long run.

Post the 1990s, the last decade has seen the financial markets in the developing economies grow by leaps and bounds. Regulatory environment was highly supportive and the trading of stock, currency, commodity and index futures was introduced in many of these nations. This has allowed many of the participants to participate in the market without having an exposure to hedge, without having the physical possession of the underlying and without any hassles through online trading terminals and platforms. The "Search for Yield" prevalent in the financial markets is thus making the commodities segment a highly attractive and appealing investment avenue.

A lot of research has been done across the globe to study the lead-lag relationships, price discovery and volatility as far as the financial markets and commodity exchanges in the Developed Nations are

concerned. Exchanges like the NYSE, DAX, etc have been the interest of researchers for a long time. Even the researches that were conducted on the indices are mainly for developed indices like the S&P 500 and FTSE 100. Less developed but rapidly transforming markets like India, China etc have been neglected till now. Although, there has been increased interest in research of Asian markets, particularly Indian markets post the 1990s, only a few
researchers have tried to study the Indian commodity indices previously, where they have got mixed results regarding the characteristic features of the commodity spot and futures markets in India.

**Significance of the Study**

This study gains its significance from the various limitations that were identified from the literature review of previously undertaken research work in this area. Some of the factors which make this study relevant and highly significant are as mentioned below:

- The time period selected for this study captures the global recession period triggered in 2008, thus gives a better understanding of the commodity market behavior during the crisis, pre crisis and post crisis periods.
- Use of Vector error Correction Model (VECM) allows the study of the causal relationships both in the short run and the long run.
- The study analyses the Indian Commodity markets, which is a country that has gained much importance in the recent times.
- The study gives insights to the policy makers and regulators of Indian commodity markets, where the trading of commodity index futures may stand to be a positive change.

**Review of Literature**

Numerous researchers have studied these stock/commodity exchanges and the price discovery process in them, volatility of their indices, so on and so forth. Some of these have been taken into study for this dissertation research work which includes study of exchanges and Stock and Commodity Market Indices from across the globe including Germany, United States of America, India, Japan, Singapore, Taiwan, China, etc.

The price variations in a single day period were examined by Kawaller et al. (1987), for the S&P 500 & the S&P 500 index futures. The findings were that throughout the trading day, a lead from futures to cash was more evident than in the opposite direction.

Using the same day minute by minute data, Pizzi et al. (1999) concluded that even though a bi directional causality existed between the S&P 500 spot index & its 3m & 6m futures, the actual study proves that futures market show atleast 20 minutes lead over the spot market.

Another study involving the spot, the index futures as well as the index options for the DAX index in Germany was conducted by Booth et al. (1999). Findings from this study suggest that spot index & index futures have a better information sharing & price discovery.

Price discovery in the Indian Custor Seed market was analysed by Thomas and Karande (2001). The daily closing data for a span of 14 years was used covering the Ahmedabad & Bombay future prices. The findings from this study indicate that two markets for the same asset can react in a totally unrelated manner to information, & one may lead the other.

A comparative study of the price discovery in Singapore & Taiwan futures exchange conducted by Roope et. al. (2002) provides strong evidence that price discovery originates mainly from the Singaporean futures market.

Five different commodities in different Indian commodity exchanges were empirically investigated for Price discovery by Kumar and Sunil (2004). They employed the Johansen cointegration technique to conclude that the futures market was not capable of incorporating information better than the spot market owing to the fact that the future market is not yet mature & efficient enough in the context of India.

**Research Objectives**

The present study has considered two objectives which are as follows:

1. To analyze the causality relationships between the spot & futures markets leading to long run equilibrium, using the "Vector Error Correction Model (VECM)".
2. To comment on the lead-lag behavior between the spot and future indices for each commodity segment

**Data Collection**

The scope of this study is limited to the Indian Commodity spot-futures markets through the collection & analysis of the index levels data for a 8 year time period starting 1 January, 2006 to 31 December, 2015 for the four major indices of the Multi-Commodity Exchange representing relevant sectors, viz. agriculture (MCXAGRI), energy (MCXENERGY), metal (MCXMETAL), and the composite index of metal, energy and agro-commodities (MCXCOMDEX). The daily closing level has been taken for the study.

All the data required for this study has been collected from the website of the Multi-Commodity Exchange, Mumbai. The data used for this study can be characterized as following:

**Source of Data:** Secondary
**Type of Data:** Financial Time-Series data
**Value of Data:** Closing levels of the AGRI, ENERGY, METAL and COMDEX indices
**Frequency of Data:** Daily data

**Research Methodology**

The methodology followed for studying the causality & modeling the volatility in the Indian commodity spot-futures markets includes the following:

- Collection of the daily closing prices of the four indices from MCX, Mumbai website for the period under study
- Preliminary Time-Series analysis of the collected data by performing the "Augmented Dickey Fuller (ADF)" unit root test for establishing & verifying the stationarity property in the price series
- The optimal lag length of the data series is decided based on the "Schwarz Information Criteria (SIC)"
- The "Johansen"s Co-integration test" is employed to test the existence of a cointegrating equation describing the long run equilibrium relationship among the spot & future prices.
- If the spot & future prices are Co-integrated, then the "Vector Error Correction Model (VECM)" is used to determine the error correction coefficients which help determine the direction of causality between the two price series.
- The coefficients are tested using the Wald Test, which help determine the direction of causality between the two price series in the long run as well as short run
- The short run causality is determined by the use of the Chi Square value, to accept or reject the Null Hypothesis about No presence of Short run Causality

**Data Analysis**

**Step 1: Preliminary Analysis**

Before proceeding with any econometric analysis or modeling, we need to check whether the given data series is stationary. This is done by conducting the Augmented Dickey Fuller (ADF) unit root test, to check the presence or absence of a unit root, thus establishing the stationarity.

**Augmented Dickey Fuller (ADF) test**

The ADF unit root test is conducted individually for all the 8 indices, the results of which have been tabulated below:

**1: Augmented Dickey Fuller (ADF) Test Results**

| ADF test Results(5% level) | | | |
|---|---|---|---|
| | **t statistic** | **Critical 't'** | **Probability** |
| **MCXAGRI** | | | |
| MCXAGRI_spot | -46.76645 | -3.41165 | 0 |
| MCXAGRI_futures | -47.9296 | -3.41165 | 0 |
| **MCXENERGY** | | | |
| MCXENERGY_spot | -50.56088 | -3.41165 | 0 |
| MCXENERGY_futures | -48.92648 | -3.41165 | 0 |
| **MCXMETAL** | | | |
| MCXMETAL_spot | -50.09125 | -3.41165 | 0 |
| MCXMETAL_futures | -52.85943 | -3.41165 | 0 |
| **MCXCOMDEX** | | | |
| MCXCOMDEX_spot | -54.83844 | -3.41165 | 0 |
| MCXCOMDEX_futures | -49.78495 | -3.41165 | 0 |

**ADF test Results(5% level)**

**Source: Self Generated Using Eviews**

**Analysis of ADF test results**

**Hypothesis:**

**Null Hypothesis:** *Unit Root exists; the series is non stationary*

**Alternate Hypothesis:** *Unit Root does not exist; the series is stationary*

**Decision rule:**

- If t* > ADF crtitical value, ==> do not reject null hypothesis, i.e., unit root exists.
- If t* < ADF critical value, ==> reject null hypothesis, i.e., unit root does not exist.

**Observations:**

From the table given above, for all the 8 indices, we can observe the following:

- The „t statistic" is smaller than the critical value &
- The probability is less than 5%

**Interpretation:**

Thus, we can safely reject the Null Hypothesis & conclude that unit root does not exist & the indices data series are thus stationary at the first difference level. Thus stationarity is verified in identical order, i.e. at first difference values & therefore econometric analysis & modeling can be further proceeded with Johansen Cointegration Test for verifying existence of a cointegrating equation.

**Step 2: Analysis of Causal Relationships**

**Johansen's Cointegration test (JCT)**

**Observations:**

We can see from the above results that the test has 2 Null Hypothesis, regarding the number of cointegrating equations that exist as follows:

- None: No cointegrating equations exist
- At Most 1: Only one cointegrating equation exists

Thus, for all the results, the following observations can be made:

- Whenever the Null Hypothesis is that "None" cointegrating equation exists, the probability value is less than 5%, & the Null Hypothesis is rejected
- But whenever the Null Hypothesis is that "At most 1" cointegrating equation exists, the probability value is greater than 5%, & the Null Hypothesis CANNOT BE rejected

**Interpretation:**

Thus now it is established that for all the MCX indices under consideration, there exists one cointegrating equation between the spot & future indices. Thus there should necessarily be a causality relationship in at least one direction.

**Step 3: Analysis of Long Run & Short Run Causality**

**Vector Error Correction Model (VECM)**

According to Granger, causality can be further sub-divided into long-run and short-run causality, the analysis of which requires the use of error correction models or VECMs (Engle Granger, 1989)

- Long-run causality is determined by the error correction term, whereby if it is significant, then it indicates evidence of long run causality from the explanatory variable to the dependent variable.

- Short-run causality is determined with a test on the joint significance of the lagged explanatory variables, using an F-test or Wald test.

The Vector Error Correction Models which were developed explains causality relationship in both directions. These models were developed by changing the dependent variable for every model. The significance of the coefficients of the error correction terms (ECT) is then tested for & final conclusions are made regarding the Long run & Short run causality between the spot & future indices.

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**MCXAGRI**

**Table 2: VECM Coefficient Values for MCXAGRI**

| MCXAGRI | | | | | |
|---|---|---|---|---|---|
| Dependent Variable | | | | | |
| MCXAGRI_SPOT | | | MCXAGRI_FUTURES | | |
| Coeff. | Value | Prob. | Coeff. | Value | Prob. |
| Long Run Causality | | | | | |
| C1 | 0.0024660 | 0.0009410 | C1 | -0.0050100 | 0.0185000 |
| Wald Test for Short Run Causality | | | | | |
| C6 | 0.0450570 | 0.0008000 | C6 | 0.3016300 | 0.0000000 |
| C7 | 0.0240560 | 0.0724000 | C7 | 0.2747120 | 0.0000000 |
| C8 | -0.0000360 | 0.9978000 | C8 | 0.0436170 | 0.1736000 |
| C9 | 0.0006610 | 0.9592000 | C9 | 0.0772510 | 0.0157000 |
| Chi Square | | 14.320 | Chi Square | | 181.04960 |
| Probability | | 0.006 | Probability | | 0.00000 |

**Source: Self Generated using Eviews**

**MCXENERGY**

**Table 3: VECM Coefficient Values for MCXENERGY**

| MCXENERGY | | | | | |
|---|---|---|---|---|---|
| Dependent Variable | | | | | |
| MCXENERGY_SPOT | | | MCXENERGY_FUTURES | | |
| Coeff. | Value | Prob. | Coeff. | Value | Prob. |
| | Long Run Causality | | | | |
| C1 | -0.096253 | 0.000100 | C1 | -0.21299 | 0.00000 |
| | Wald Test for Short Run Causality | | | | |
| C6 | -0.002975 | 0.928100 | C6 | 0.167447 | 0.0 |
| C7 | -0.016864 | 0.580400 | C7 | 0.337895 | 0.0 |
| C8 | 0.026304 | 0.297400 | C8 | 0.225864 | 0.0 |
| C9 | 0.045984 | 0.041400 | C9 | 0.094378 | 0.0 |
| Chi Square | | 5.9834110 | Chi Square | | 300.1 |
| Probability | | 0.2004000 | Probability | | 0.0 |

**Source: Self Generated using Eviews**

**MCXMETAL**

**Table 4: VECM Coefficient Values for MCXMETAL**

| MCXMETAL | | | | | |
|---|---|---|---|---|---|
| Dependent Variable | | | | | |
| MCXMETAL_SPOT | | | MCXMETAL_FUTURES | | |
| Coeff. | Value | Prob. | Coeff. | Value | Prob. |
| Long Run Causality | | | | | |
| C1 | 0.0058730 | 0.7972000 | C1 | -0.275034 | 0.000000 |
| Wald Test for Short Run Causality | | | | | |
| C6 | 0.041168 | 0.1372000 | C6 | 0.115877 | 0.000 |
| C7 | -0.006676 | 0.7947000 | C7 | 0.299969 | 0.000 |
| C8 | 0.052552 | 0.0147000 | C8 | 0.213351 | 0.000 |
| C9 | 0.008927 | 0.6406000 | C9 | 0.082692 | 0.000 |
| Chi Square | | 9.7695220 | Chi Square | | 180.745 |
| Prob. | | 0.0445000 | Prob. | | 0.000 |

**Source: Self Generated using Eviews**

**MCXCOMDEX**

**Table 5: VECM Coefficient Values for MCXCOMDEX**

| MCXCOM DEX | | | | | |
|---|---|---|---|---|---|
| Dependent Variable | | | | | |
| MCXCOMDEX_SPOT | | | MCXCOM DEX_FUTURES | | |
| Coeff. | Value | Prob. | Coeff. | Value | Prob. |
| Long Run Causality | | | | | |
| C1 | 0.004355 | 0.704800 | C1 | -0.054754 | 0.000000 |
| Wald Test for Short Run Causality | | | | | |
| C6 | 0.1152990 | 0.00010 | C6 | 0.3590430 | 0.0000000 |
| C7 | 0.0794310 | 0.00680 | C7 | 0.4014740 | 0.0000000 |
| C8 | 0.0711060 | 0.00710 | C8 | 0.2498090 | 0.0000000 |
| C9 | 0.0301740 | 0.19830 | C9 | 0.0967240 | 0.0000000 |
| Chi Square | | 20.72083 | Chi Square | | 647.46820 |
| Probability | | 0.00040 | Probability | | 0.00000 |

**Source: Self Generated using Eviews**

**Decision Rules:**

For Long Run causality

- C(1): should be negative & probability less than 5%, i.e. 0.0500 For Short Run causality
- C(6), C(7), C(8) & C(9): should jointly be significant if for the Wald Test for joint significance of coefficients, i.e. the Chi-Square statistic probability is less than 5%, i.e. 0.0500

The various causal relationships found between the spot & futures series for the various indices has been summarized & tabulated below for easier comprehension:

**Table 6: Summary of Long & Short Run Causality Relationships**

| | Short Run Causality | Long Run Causality |
|---|---|---|
| **MCXAGRI** | Bidirectional | Unidirectional |
| | MCXAGRI_spot <---> MCXAGRI_futures | MCXAGRI_spot ---> MCXAGRI_futures |
| **MCXENERGY** | Unidirectional | Bidirectional |
| | MCXENERGY_spot ---> MCXENERGY_futures | MCXENERGY_spot <---> MCXENERGY_futures |
| **MCXMETAL** | Bidirectional | Unidirectional |
| | MCXMETAL_spot <---> MCXMETAL_futures | MCXMETAL_spot ---> MCXMETAL_futures |
| **MCXCOMDEX** | Bidirectional | Unidirectional |
| | MCXCOMDEX_spot <---> MCXCOMDEX_futures | MCXCOMDEX_spot ---> MCXCOMDEX_futures |

**Conclusions**

By the use of the Vector Error Correction Model this study has successfully differentiated and helped in analyzing the reasons behind the exact movements in the long run and short run. In the long run, we find that the spot leads and causes the futures market for all segments except Energy, where the causality also exists from the Futures market to the Spot, owing to its dependence on global supply and demand conditions, rather than just local conditions. Thus the effect of Futures trading is more pronounced & evident in the case of Energy segment. On the other hand, we find that the same may not apply to the other segments such as the Agricultural commodities, because the majority of agricultural commodities are highly dependent only on the local supply and demand conditions.

Another factor which the paper justifies is the presence of bi directional causality in Energy segment unlike other segments is that the Government provides subsidies for the commodities in the Energy segment unlike the others such as the Metal or Agricultural segments. Thus for the investors, consumers & producers it is easier to anticipate and estimate the spot prices in the case of Non subsidized commodities. The Price Discovery is more efficient through the spot markets, and expectations are formed directly by buying and selling in the spot markets. While in the case of the subsidized commodities from the Energy segment, the prices are not really transparent for all market participants alike and there is always an uncertainty involved in the form of changing government policies and changing global demand and supply. futures play a key role in the price discovery process

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