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PRICE DISCOVERY AND VOLATILITY SPILLOVER IN METAL COMMODITY MARKET IN INDIA

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ABSTRACT

This study examines the price discovery and volatility spillovers between futures and spot prices of ten metal commodities viz., Aluminium, Copper, Iron Ore, Lead, Nickel, Sponge Iron, Steel Flat, Thermal Coal, Tin and Zinc, traded on Multi Commodity Exchange (MCX) Ltd., Mumbai. The study uses the daily data from 15th January 2004 to 31st March 2015. The empirical results confirm the price discovery between futures and spot prices, indicating strong information transmission from futures markets to spot markets in the case of majority of metal commodities. The feedback spillover effect exists between spot and futures market prices in majority of the underlying commodities that belongs to Metals. Besides, the study results suggest that the volatility spillover effects are found to be quite strong between spot and futures markets in the case of majority Metal commodities. The present study concludes that India's agriculture commodity derivatives market is evolving in the right direction as futures market has started playing crucial role in the information transmission process.

KEYWORDS: *Price Discovery, Volatility Spillover, Metal Commodities, VECM, Bivariate EGARCH.*

Introduction

The concept of trading in commodities is not new to India, as trading in commodities was very much in existence even during ancient times. It is well documented as one the most efficient forms of markets until the early 1970s. However, due to the numerous restrictions on trading, growth of commodity markets remained underdeveloped. Recently several of these crippling restrictions have been done away with, and this has led to novel developments and vibrant growth of the Indian commodity markets. Commodities play a noteworthy role in the economic development of our country. After liberalization of the Indian economy in the year 1991, a series of measures were taken to open-up the commodity derivatives market. A very noteworthy step being the setting up of multi commodity exchanges at the national level, as per the proposal made by the then market regulator, the Forwards Market Commission (FMC).

The issue of price discovery and the volatility spillover is of great interest to traders, financial economists and analysts. Although futures and spot markets react to same information, the major question is which market reacts first and from which market volatility spills over to other markets. The process of price discovery facilitates the inter-temporal inventory allocation function by which market participants are able to compare the current and futures prices and decide the optimal allocation of their stocks between immediate sale and storage for futures sale. Unlike the physical market a futures market facilitates offsetting the traders without exchanging physical goods until the expiry of a contract. As a result, futures market attracts hedgers for risk management and encourages considerable external competition from those who possess market information and price judgment to trade as traders in these commodities. While hedgers have long-term perspective of the market, the traders or arbitragers prefer an immediate view of the market.

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Moreover, understanding information flow across markets is important for hedge funds, portfolio managers and hedgers for hedging and devising cross-market investment strategies. Specifically, the investigation of price discovery and volatility spillover will throw light on the possibility of acting spot or future prices as an efficient price discovery vehicle, and this will be immensely useful for the traders to hedge their market risk. Besides, it provides useful insights to the arbitrageurs, who are formulating their trading strategies based on market imperfections. Further, the subject is immensely helpful for the investors and portfolio managers to develop effective trading and hedging strategies in the Indian commodity futures market. Keeping in view the above, the present study examines the price discovery in Indian metal commodity futures and spot market and to investigate whether the volatility spills over from futures to spot market or vice versa. The remainder of the paper is organised as follows: Section 2 provides the review of literature. Section 3 describes the methodology and data used for empirical analysis. Section 4 offers empirical results and discussion of the study. Conclusions are presented in section 5.

Review of Literature

Thomas and Karande (2001) analyzed price discovery in India's castor seed market in Ahmedabad and Mumbai, by using daily closing data on futures and spot prices, which span from May 1985 to December 1999. They found that out of four, three seasonal contracts in Mumbai futures prices lead the Ahmedabad futures prices, while the March contract in Ahmedabad futures prices lead the former one. Hamaoetal (1990) found volatility spillover exists from the United States and United Kingdom stock markets to the Japanese stock markets. Susmel and Engle(1994) examined the spillover effect for London and NewYork stock exchanges and suggested that there is no evidence of spillovereffect. Theodossiouand Lee (1993) observed statistically significant mean and volatility spillovers between some of the markets in the United States, United Kingdom, Canada, Germany and Japan. Koutmos and Booth (1995) found linkages between the developed markets and concluded that the volatility transmission process was asymmetric. Booth et al.(1997) examined the price and volatility spillovers in Scandinavian stock markets, viz. Danish, Norwegian, Swedish, and Finnish stock markets by employing the EGARCH model. They found that volatility transmission was asymmetric, significant price and volatility spillovers exist among some of the markets. Moosa (2002) examined the price discovery function and risk transfer in crude oil market by using Garbade and Silber (1983) model. 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 price discovery function was performed in futures market. Kumar and Sunil (2004) investigated the price discovery in six Indian commodity exchanges for five commodities. They found that inability of futures market to fully incorporate information and confirmed inefficiency of futures market.

Zhong et al.(2004) investigated whether 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. By using VECM and EGARCH models, the empirical evidence showed that the futures price index acts as a useful price discovery vehicle and futures trading had also been a source of instability for the spot market. Zapata et al.(2005) examined the relationship between eleven futures contract prices traded in New York and the World cash prices for exported sugar. They found that the futures market for sugar leads the cash market in price discovery mechanism. Fu and Qing (2006) examined the price discovery process and volatility spillovers in Chinese spot-futures markets through Johansen cointegration, VECM and EGARCH model. The empirical results indicate significant bidirectional information flows between spot and futures markets in China, with futures being dominant. Besides, the volatility spillovers from futures to spot were more significant than the other way round. Praveen and Sudhakar (2006) analyzed price discoveryprocess in stock market and the commodity futures market, respectively. They have taken Nifty futures traded on National Stock Exchange (NSE) and gold futures on Multi Commodity of India (MCX). The result showed that the Nifty futures had no influence on the spot Nifty. Besides, the analysis of commodity market showed that gold futures price influenced the spot gold price, but not the other way round. Srinivasan (2009) examined the price discovery mechanism in the Nifty spot and futures market of India. The results reveal that there exists a long-run relationship between Nifty spot and Nifty futuresprices.

Further, the results confirm the presence of a bidirectional relationship between the Nifty spot and Nifty futures market prices in India. It can, therefore, be concluded that both the spot and futures markets play the leading role through price discovery process in India and said to be informationally efficient and react more quickly to each other. Iyer and Pillai(2010) had examined whether futures markets play a dominant role in the price discovery process. They found that commodity futures market prices play the vital role in the price discovery process. Besides, Shihabudheen and Padhi (2010) examined the price discovery mechanism and volatility spillovers effect for six Indian commodity markets, *viz.*, Gold, Silver, Crude oil, Castor seed, Jeera and Sugar. The study result supported that futures price acts as an efficient price discovery vehicle except in the case of sugar. In case of sugar, the volatility spillover exists from spot to futures. Moreover, Pavabutr and Chaihetphon (2010) examined the price discovery process of the nascent gold futures contracts in the Multi Commodity Exchange of India (MCX) though vector error correction model. They found that futures prices of both standard and mini contracts lead spot price. Recently, Kumarand Shollapur (2015) analyzed the price behavior in terms of returns as well as volatility between the spot and futures markets for four commodities, *viz.* soya oil, soya bean, mustard seed and channa. They found existence of long-term equilibrium relationship between the futures and spot prices, with the futures leading the spot prices. In the short run, futures returns seem to have a stronger impact on the spot returns in most of thecommodities.

It can seen be from the existing literatures on price discovery and volatility spillover that even though spot and futures markets react to the same information, the major question is which market reacts first. Considerable volume of research has been conducted on the subject, but still there exist conflicting evidences in the literature regarding the price discovery mechanism and volatility spillover effects. Besides, only a few notable studies have made an attempt on Indian commodity market with reference to individual metal commodity futures. This paper seeks to contribute to the literature on price discovery and volatility spillovers by focusing on the selected ten metal commodities viz., Aluminium, Copper, Iron Ore, Lead, Nickel, Sponge Iron, Steel Flat, Thermal Coal, Tin and Zinc, traded on Multi Commodity Exchange (MCX) Ltd., Mumbai.

Methodology

Johansen's (1988) cointegration approach and Vector Error Correction Model (VECM) have been employed to investigate the price discovery process in spot and futures market of metal commodities in India. Before doing cointegration analysis, it is necessary to test the stationary of the series. The Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) tests were employed to infer the stationary of the series. If the series are non-stationary in levels and stationary in differences, then there is a chance of cointegration relationship between them which reveals the long-run relationship between the series. Johansen's cointegration test has been employed to investigate the long-run relationship between two variables. Besides, the causal relationship between spot and futures prices investigated by estimating the following Vector Error Correction Model (VECM). As volatility responds to good and bad news, EGARCH specification popularized by Nelson (1991) is applied. Besides the EGARCH representation was employed to capture the leverage effect found in the returns series, and to avoid imposing non-negativity restrictions on the values of the GARCH parameters to be estimated. In this study, the Bivariate EGARCH (1,1) model is used to test for volatility spillovers between two markets,

- from spot to futures market and
- from futures to spot market.

The sample used in the study consists of ten metal commodities viz., Aluminium, Copper, Iron Ore, Lead, Nickel, Sponge Iron, Steel Flat, Thermal Coal, Tin and Zinc, traded on Multi Commodity Exchange (MCX) Ltd., Mumbai. The period of study is from 15th January 2004 to 31st March 2015. However the data period varies across commodities owing to their late introduction on trading exchanges and the fact that some metal 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 daily closing spot and futures prices of the selected ten metal commodities viz., Aluminium, Copper, Iron Ore, Lead, Nickel, Sponge Iron, Steel Flat, Thermal Coal, Tin and Zinc. All the required data information for the study has been retrieved from the website of Multi Commodity Exchange (MCX) Ltd., Mumbai. The list of sample commodities as well as their data period is given in the following Table 1.

Table 1: List of Sample Metal Commodities Selected for the Study

S. No.	Name of the Metal Commodity	Study Period
1.	Aluminium	1st February 2007 to 31st March 2015
2.	Copper	23rd December 2006 to 31st March 2015
3.	Iron Ore	29th January 2011 to 31st December 2012
4.	Lead	1st February 2007 to 31st March 2015
5.	Nickel	8th February 2007 to 31st March 2015

6.	Sponge Iron	16th January 2007 to 15th June 2009
7.	Steel Flat	16th February 2007 to 15th June 2009
8.	Thermal Coal	9th January 2009 to 6th December 2012
9.	Tin	1st January 2007 to 29th June 2012
10.	Zinc	1st January 2007 to 31st March 2015

Empirical Findings

As a preliminary step, Table 2 presents the results of descriptive statistics of spot and futures market returns of each individual commodity that belongs to metal sector of commodities market. The table result depicts that the futures markets provides relatively high returns than the spot markets in the case of majority of the underlying metal commodities. The values of standard deviation indicate that the volatility nature of all underlying metal commodities was found to be higher. Further, the table results reveal that the skewness statistics of futures and spot market returns of all metal commodities are significantly different from zero *i.e.* they are skewed either to the right or to the left. Also, the excess kurtosis values of all futures and spot return series of selected metal commodities are fat-tailed or leptokurtic compared to the normal distribution. In addition, the Jarque-Bera test statistics indicate that the null hypothesis of normality of return series of all selected metal commodities had been rejected at one per cent significance level. Hence, it can be concluded that the futures and spot market return series of all selected metal commodities were significantly departed from normality.

Table 2: Descriptive Statistics for Metal Commodity Spot and Future Markets

Statistics	Aluminium		Copper		Iron ORE		Lead	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	-5.29E-05	-4.00E-05	0.000129	0.000107	-2.84E-05	-0.000409	0.000165	0.000159
Median	0.000000	0.000000	0.000000	0.000124	0.000000	0.000000	0.000000	0.000000
Maximum	0.122538	0.080417	0.100096	0.089850	0.127389	0.078435	0.240596	0.106160
Minimum	-0.318960	-0.332048	-0.135687	-0.108812	-0.107258	-0.075707	-0.114564	-0.128827
Std. Dev.	0.014229	0.016308	0.018247	0.015659	0.015091	0.014469	0.022294	0.018945
Skewness	-4.820240	-3.288362	-0.251598	-0.300630	1.338497	-0.407355	0.347140	-0.377652
Kurtosis	116.9211	78.01704	7.996697	8.961293	21.41105	10.58368	11.77955	9.412074
Jarque-Bera Statistics	1260803* (0.0000)	546996.9* (0.0000)	2388.562* (0.0000)	3399.890* (0.0000)	7946.635* (0.0000)	1335.624* (0.0000)	7358.750* (0.0000)	3954.881* (0.0000)
Statistics	NICKEL		SPONGE IRON		STEEL FLAT		THERMAL COAL	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	-0.000283	-0.000324	2.63E-05	7.18E-05	0.000123	0.000130	0.000446	0.000480
Median	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.281468	0.172761	0.172930	0.185633	0.039701	0.050867	0.198092	0.181886
Minimum	-0.158959	-0.146850	-0.103684	-0.158437	-0.045715	-0.079203	-0.212587	-0.172371
Std. Dev.	0.021450	0.019150	0.016836	0.017874	0.008109	0.010122	0.047294	0.041804
Skewness	0.444465	-0.061068	1.101847	-1.060048	0.257799	-1.600397	0.002041	0.175142
Kurtosis	21.57245	11.58356	26.30547	48.11952	9.517591	18.22217	7.414678	6.946093
Jarque-Bera Statistics	36387.67* (0.0000)	7756.126* (0.0000)	14065.36* (0.0000)	52366.83* (0.0000)	1072.183* (0.0000)	6069.151* (0.0000)	681.3168* (0.0000)	548.6481* (0.0000)
Statistics	TIN		ZINC					
	Spot Returns	Futures Returns	Spot Returns	Futures Returns				
Mean	0.000475	0.000472	-0.000162	-0.000197				
Median	0.000000	0.000000	0.000000	0.000000				
Maximum	0.285798	0.116782	0.129644	0.157603				
Minimum	-0.131652	-0.136142	-0.156335	-0.120429				
Std. Dev.	0.022239	0.015182	0.018257	0.017702				
Skewness	0.994868	0.100871	-0.301530	0.128353				
Kurtosis	24.02675	13.32082	8.797312	8.575944				
Jarque-Bera Statistics	28289.10* (0.0000)	6757.679* (0.0000)	3564.282* (0.0000)	3268.894* (0.0000)				

The unit root property of the data series is crucial for the cointegration and causality analyses. The standard Augmented Dickey–Fuller (ADF) and Phillips–Perron(PP) tests are employed to examine stationary property of the selected data series. Table 3 depicts the results of Augmented Dickey-Fuller and Phillips-Perron tests for the spot and futures markets price series of the each underlying metal commodities. Both the unit root test results shows that the price series of the respective underlying commodities are stationary at their first difference, indicating that the spot and futures price series of each respective commodities are integrated at order one, *i.e.*, *I*(1).

Table 3: Results of Unit Root Test

Name of the Commodity	Market	Augmented Dickey-Fuller Test Statistics		Phillips-Perron Test Statistics	
		Level	First Difference	Level	First Difference
Aluminium	Spot	-1.90	-43.21*	-1.04	-43.37*
	Futures	-1.23	-42.63*	-1.19	-46.70*
Copper	Spot	-1.73	-51.92*	-1.77	-51.87*
	Futures	-1.62	-47.17*	-1.71	-47.85*
Iron ORE	Spot	-1.58	-31.84*	0.21	-31.54*
	Futures	-1.48	-31.72*	0.25	-31.56*
Lead	Spot	-2.06	-32.10*	0.42	-32.09*
	Futures	-2.10	-22.14*	0.40	-22.14*
Nickle	Spot	-0.94	-22.32*	-0.58	-21.01*
	Futures	-1.02	-42.45*	-0.52	-41.04*
Sponge iron	Spot	-2.40	-41.40*	0.60	-42.52*
	Futures	-2.38	-41.54*	0.50	-42.50*
Steel flat	Spot	-21.81	-3.08*	-0.30	-21.87*
	Futures	-21.96	-3.07*	-0.29	-21.75*
Thermal coal	Spot	-0.66	-41.71*	-0.68	-40.77*
	Futures	-0.64	-41.66*	-0.69	-40.76*
Tin	Spot	-2.05	-32.21*	-0.35	-32.08*
	Futures	-2.10	-22.26*	-0.36	-22.13*
Zinc	Spot	-1.52	-53.27*	-0.45	-51.50*
	Futures	-1.40	-53.10*	-0.43	-51.27*

Notes:* indicates significance at one per cent level. Optimal lag length is determined by the Schwarz Information Criterion (SIC) and Newey-West Criterion for the Augmented Dickey-Fuller Test and Phillips-Perron Test respectively.

Johansen's Cointegration test is done to examine the presence of long-run relationship between spot and futures market prices of underlying commodities of metal sector and its results are presented in Table 4.

Table 4: Results of Johansen's Co-integration Test

Name of the Stocks	vector (*r*)	Trace Statistics (λ_{trace})	5 % critical value for λ_{trace} test	Max-EigenStatistics (λ_{max})	5 % critical value for λ_{max} test	Remarks
Aluminium	H_0: r = 0**	22.40712	25.87211	19.9024	19.38704	*Co-integrated*
	H_1: r ≥ 1	11.10065	12.51798	15.10406	12.51798	
Copper	H_0: r = 0**	28.10406	25.87211	31.16574	19.38704	*Co-integrated*
	H_1: r ≥ 1	10.0134	12.51798	6.36882	12.51798	
Iron ORE	H_0: r = 0**	26.05457	25.87211	41.24788	19.38704	*Co-integrated*
	H_1: r ≥ 1	12.25790	12.51798	6.48892	12.51798	
Lead	H_0: r = 0**	28.34039	25.87211	40.24765	19.38704	*Co-integrated*
	H_1: r ≥ 1	10.34173	12.51798	7.36787	12.51798	
Nickle	H_0: r = 0**	27.54033	25.87211	31.25673	19.38704	*Co-integrated*
	H_1: r ≥ 1	10.12105	12.51798	10.4378	12.51798	
Sponge iron	H_0: r = 0**	28.56808	25.87211	25.2487	19.38704	*Co-integrated*
	H_1: r ≥ 1	6.78715	12.51798	11.247882	12.51798	
Steel flat	H_0: r = 0**	28.5443	25.87211	21.27892	19.38704	*Co-integrated*
	H_1: r ≥ 1	11.83214	12.51798	7.27543	12.51798	
Thermal coal	H_0: r = 0**	28.3406	25.87211	19.4957	19.38704	*Co-integrated*
	H_1: r ≥ 1	4.84486	12.51798	4.84486	12.51798	
Tin	H_0: r = 0**	29.3286	25.87211	21.86543	19.38704	*Co-integrated*
	H_1: r ≥ 1	9.32997	12.51798	11.1368	12.51798	
Zinc	H_0: r = 0**	35.9497	25.87211	20.5525	19.38704	*Co-integrated*
	H_1: r ≥ 1	10.39727	12.51798	10.39727	12.51798	

Notes:** indicates significance at five per cent level. The significant of the statistics is based on 5 per cent critical values obtained from Johansen and Juselius (1990). r is the number of cointegrating vectors. H_0 represents the null hypothesis of presence of no cointegrating vector and H_1 represents the alternative hypothesis of presence of cointegrating vector.

The table result of Johansen's maximum Eigen and Trace statistics indicates the presence of one cointegrating vector between the futures and spot market prices at 5% level in case of each selected individual commodities of metal sector, respectively. The Johansen's cointegration test confirms the existence of long-run relationship between the spot and futures prices of each underlying metal commodities in India.

Existence of long-run relationship between two markets has very important implications for the traders in futures market. Existence of cointegration suggests that although both markets may be in disequilibrium during the short-run but such deviations are very quickly corrected through arbitrage process and the hedgers may take long-run positions to hedge market risk to the maximum extent. In order to check whether short-run disequilibrium exists, Vector Auto regression (VAR) based on VECM has been applied. Kroner and Sultan (1993) shows that if the spot and futures prices are cointegrated, there must be an error correction representation that includes both the short term dynamics and long term information. For the purpose, the causality between spot and futures prices for respective agriculture commodities was estimated by using the Vector Error Correction Model (VECM) and its result are depicted in Table5.

Table 5: Results of Vector Error Correction Model

	Aluminium		Copper		Iron ORE		Lead	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.162764* (0.01939) [-8.39216]	0.098189* (0.02151) [4.56501]	-0.237239* (0.01521) [-15.5970]	0.041819*** (0.02263) [1.84815]	0.039809 (0.03285) [1.21182]	0.214783* (0.02870) [7.48283]	-0.268082* (0.02609) [-10.2735]	0.150307* (0.02464) [6.09990]
ΔS_{t-1}	-0.135979* (0.02423) [-5.61271]	0.185504* (0.02687) [6.90426]	-0.106235* (0.01270) [-8.36702]	0.017942 (0.01889) [0.94994]	0.167933* (0.05761) [2.91476]	0.178193* (0.05034) [3.53973]	-0.179697* (0.02603) [-6.90413]	- 0.045177*** (0.02458) [-1.83812]
ΔS_{t-2}	---	---	---	---	0.078067 (0.05736) [1.36097]	0.008532 (0.05012) [0.17023]	---	---
ΔF_{t-1}	0.108149* (0.02246) [4.81496]	-0.354320* (0.02491) [-14.2242]	0.720796* (0.01934) [37.2648]	0.029339 (0.02877) [1.01962]	0.084530 (0.05586) [1.51322]	0.045540 (0.04881) [0.93303]	0.452265* (0.03104) [14.5702]	0.175217* (0.02931) [5.97777]
ΔF_{t-2}	---	---	---	---	-0.014262 (0.05247) [-0.27181]	0.041268 (0.04584) [0.90018]	---	---
c	-4.78E-05 (0.00028) [-0.16821]	-4.01E-05 (0.00032) [-0.12717]	5.67E-05 (0.00022) [0.25681]	9.47E-05 (0.00033) [0.28829]	1.30E-05 (0.00062) [0.02091]	-0.000321 (0.00054) [-0.59169]	0.000124 (0.00042) [0.29936]	0.000135 (0.00039) [0.34494]
Inference	F↔S (LR) F↔S (SR)		F↔S (LR) F→S (SR)		S→F (LR) S→F (SR)		F↔S (LR) F↔S (SR)	

	Nickel		Sponge Iron		Steel Flat		Thermal coal	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.172307* (0.02372) [-7.26382]	0.073571* (0.02335) [3.15014]	0.001526 (0.00970) [0.15729]	0.050493* (0.01009) [5.00545]	0.031678* (0.01136) [2.78772]	0.093990* (0.01360) [6.91143]	-0.570173* (0.10604) [-5.37672]	0.003528 (0.09615) [0.03670]
ΔS_{t-1}	-0.318463* (0.03013) [-10.5706]	-0.029546 (0.02966) [-0.99611]	0.110889* (0.04203) [2.63835]	0.070125*** (0.04370) [1.67457]	0.004736 (0.04377) [0.10819]	0.097273*** (0.05238) [1.85697]	-0.117164 (0.09183) [-1.27590]	0.028205 (0.08326) [0.33877]
ΔS_{t-2}	-0.170177* (0.02627) [-6.47796]	-0.032750 (0.02586) [-1.26621]	---	---	---	---	---	---
ΔF_{t-1}	0.492065* (0.03233) [15.2200]	0.105450* (0.03183) [3.31285]	0.040561 (0.03873) [1.04734]	0.065511*** (0.04027) [1.67682]	0.080036* (0.03336) [2.39899]	0.060578 (0.03993) [1.51725]	- 0.105533*** (0.09874) [-1.66883]	- 0.276493* (0.08952) [-3.08863]
ΔF_{t-2}	0.242394* (0.03113) [7.78753]	0.015813 (0.03064) [0.51601]	---	---	---	---	---	---
c	-0.000184 (0.00039) [-0.47549]	-0.000304 (0.00038) [-0.79573]	2.08E-05 (0.00068) [0.03077]	6.65E-05 (0.00070) [0.09463]	9.79E-05 (0.00033) [0.29895]	0.000110 (0.00039) [0.28067]	0.000551 (0.00155) [0.35590]	0.000620 (0.00140) [0.44231]
Inference	F↔S (LR) F↔S (SR)		S→F (LR) S→F (SR)		F↔S (LR) F↔S (SR)		F→S (LR) F→S (SR)	

	TIN		ZINC		
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	
ECT	-0.025960 (0.02272) [-1.14234]	0.224894* (0.01402) [16.0394]	-0.172563* (0.02322) [-7.43049]	0.107783* (0.02462) [4.37846]	
ΔS_{t-1}	-0.015371 (0.03192) [-0.48151]	0.004125*** (0.01970) [1.70945]	-0.300951* (0.02862) [-10.5145]	0.028386 (0.03034) [0.93562]	
ΔS_{t-2}	---	---	-0.202237* (0.02394) [-8.44705]	-0.108632* (0.02538) [-4.28059]	
ΔF_{t-1}	0.005360 (0.04179) [0.12827]	-0.007378 (0.02578) [-0.28615]	0.442519* (0.02976) [14.8678]	-0.056315*** (0.03155) [-1.78502]	
ΔF_{t-2}	---	---	0.306490* (0.02712) [11.3029]	0.182429* (0.02874) [6.34696]	
c	0.000501 (0.00057) [0.87699]	0.000475 (0.00035) [1.34704]	-3.84E-05 (0.00033) [-0.11799]	-0.000148 (0.00035) [-0.42851]	
Inference	S→F (LR) S→F (SR)		F↔S (LR)		

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SC), F_t and S_t are the Futures and Spot market prices respectively, *, ** and *** denote the significance at the one, five and ten per cent level, respectively. [ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

The estimates of Vector Error Correction Model show the mixed evidence. The findings of underlying commodities of metals reveals long-run bidirectional causation between futures and spot market prices for the Aluminium, Copper, Lead, Nickel, Steel Flat and Zinc, long-run unilateral causation from futures to spot price and reverse in case of Thermal Coal and Iron Ore, Sponge Iron and Tin, respectively. Besides the VECM table result shows the short-run bidirectional relationship between spot and futures markets in the case of five metal stocks, viz. Aluminium, Nickel, Lead Steel Flat and Zinc. This shows that both the spot and future markets is efficient with regard to the information and is able to react immediately with each other. The analysis also confirms that spot leads to futures price and futures leads to spot market price in the case of Iron Ore, Sponge Iron and Tin and Copper and Thermal Coal, respectively. Regarding the examination of Volatility Spillover effects in the Indian metal commodity markets, Engle (1982) ARCH-LM test statistics was conducted in order to test the null hypothesis of no ARCH effects and its results are reported in the Table-6. The test statistics are highly significant at one percent levels, confirming the existence of significant ARCH effects on the futures and spot return data series of all selected underlying commodities of metal sector. The spot and futures return series of all selected underlying commodities of metal appear to be best described by an unconditional leptokurtic distribution and possesses significant ARCH effects which is confirmed by ARCHLM test statistics, *i.e.* volatility clustering. This suggests that the Bivariate EGARCH model is capable with generalised error distribution (GED) is deemed fit for modeling the spot and futures return volatility of these commodities, as it sufficiently captures the volatility clustering and heteroscedastic effects. Table 7 shows the estimates of Bivariate EGARCH model to determine the volatility spillover mechanism takes place between spot and futures commodity markets of respective commodities that belongs to metal sector.

Table 6: ARCH LM Test Results for Spot and Futures Agricultural Commodity Markets

Name of the Commodity	ARCH LM Statistics			
	Spot Returns	Prob. Value	Futures Returns	Prob. Value
	Agriculture			
Aluminium	99.636	0.000	679.99	0.000
Copper	45.324	0.000	53.975	0.000
Iron ORE	630.67	0.000	46.567	0.000
Lead	664.65	0.000	119.20	0.000
Nickel	99.636	0.000	679.99	0.000
Sponge Iron	45.324	0.000	53.975	0.000
Steel Flat	630.67	0.000	46.567	0.000
Thermal coal	664.65	0.000	119.20	0.000
Tin	99.636	0.000	679.99	0.000
Zinc	45.324	0.000	53.975	0.000

Note: ARCH-LM is a Lagrange multiplier test for ARCH effects in the residuals (Engle, 1982).

The empirical evidence from Table 7 reveals that the GARCH effects for all the commodities are statistically significant, implying the degree of volatility persistence exists in the case of both futures and spot market returns of respective commodities that belongs to metals. This result suggests that once a shock has occurred, volatility tends to persist for long periods in both the spot and futures markets of respective metal commodity. The leverage effect parameters are statistically significant for both futures and spot market returns of respective metal commodities, indicating existence of leverage effect. This indicates that negative shocks have a greater impact on conditional volatility than positive shocks of equal magnitude in the case of respective commodities of metals. This means that volatility is higher after negative shocks (bad news) rather than after positive shocks (good news) of the same magnitude.

Table 7: Results of Bivariate EGARCH Model

Name of the Stocks	Market	ω_i	ψ_i	α_i	γ_i	τ_i	ARCH-LM Statistics	Inference
Aluminium	Spot	-0.01362 (-0.9080)	-0.3735* (-7.2996)	0.9620* (50.34)	0.1463* (10.460)	-0.0026** (-2.3199)	0.9520 [0.3292]	
	Futures	0.0301 (1.5911)	-2.4621* (-13.072)	0.8653* (26.836)	0.3990* (14.377)	-0.0171** (-1.9650)	0.4491 [0.8141]	F↔S
Copper	Spot	-0.058** (-1.978)	-0.094* (-7.452)	0.988* (39.80)	0.1753** (2.451)	-0.048* (-3.309)	0.2176 [0.4730]	
	Futures	0.084* (3.509)	-1.974* (-17.73)	0.866* (52.08)	0.0609 (1.120)	-0.192* (-11.17)	0.1141 [0.7355]	F→S
Iron ORE	Spot	0.018** (2.112)	-6.514* (-18.19)	0.207* (7.374)	0.0556 (1.560)	-0.148* (-7.472)	0.0114 [0.9249]	
	Futures	0.018** (2.170)	-0.534* (-8.419)	0.951* (12.94)	0.2237* (4.257)	-0.053* (-6.233)	1.6015 [0.1692]	S→F
Lead	Spot	-0.127* (-7.681)	-9.826* (-36.26)	-0.060* (-4.224)	1.405* (40.06)	-0.215* (-8.436)	0.0584 [0.7090]	
	Futures	0.194* (11.18)	-4.854* (-30.98)	0.301* (11.95)	1.031* (22.09)	-0.421* (-24.28)	0.0291 [0.9431]	F↔S
Nickle	Spot	0.0451* (2.5105)	-1.0294* (-8.188)	0.8687* (15.882)	0.2083* (8.5179)	-0.0092 (-0.5239)	0.4083 [0.6228]	
	Futures	-0.0047 (-0.9636)	-1.1366* (-6.2355)	0.8164* (17.487)	-0.0418* (-3.5764)	-0.1261* (-9.2455)	0.0136 [0.8593]	F↔S
Sponge Iron	Spot	0.0154 (1.0647)	-0.5839* (-10.316)	0.9329* (132.36)	0.1375 (1.222)	-0.0136 (-0.4607)	0.0288 [0.3988]	
	Futures	0.0203 (0.4254)	-0.4871* (-10.121)	0.8552* (19.24)	0.4230* (4.616)	-0.0366* (-4.8831)	0.5890 [0.2075]	S→F
Steel Flat	Spot	0.0237** (2.3986)	-0.5418* (-7.8585)	0.8610* (15.09)	0.2156* (13.458)	-0.0202* (-2.8977)	0.7736 [0.1313]	
	Futures	0.0510** (2.1905)	-1.722* (-8.4187)	0.5642* (16.913)	0.4398* (10.952)	-0.0396** (-1.9706)	0.0134 [0.9924]	F↔S
Thermal Coal	Spot	0.0587** (2.3277)	-0.4007* (-7.1087)	0.9695* (13.51)	0.3743** (1.981)	-0.0541* (-5.9461)	0.0124 [0.9349]	
	Futures	0.0005 (0.0445)	-0.1219* (-4.9842)	0.9424* (12.72)	0.0987 (1.583)	-0.04981* (-7.6069)	0.0348 [0.8520]	F→S
Tin	Spot	0.0408* (2.6526)	-0.4202* (-10.797)	0.9475* (14.23)	0.0192 (1.073)	-0.0252* (-2.9337)	1.2330 [0.1965]	
	Futures	0.0364 (0.2973)	-0.9459* (-9.3724)	0.8921* (17.522)	0.2469* (4.484)	-0.02315* (-2.8363)	0.4351 [0.8242]	S→F
Zinc	Spot	-0.01362 (-0.9080)	-0.3735* (-7.2996)	0.9620* (15.34)	0.1463* (10.560)	-0.0126** (-2.3199)	0.9520 [0.3292]	F↔S
	Futures	0.0301 (1.5911)	-2.4621* (-13.072)	0.8753* (17.836)	0.3790* (15.377)	-0.0371* (-2.9750)	0.9198 [0.8141]	

Notes: Figures in ( ) parentheses are z-statistics. * (**) denote the significance at the one and five per cent level, respectively. Figures in [ ] indicates the probability value of ARCH LM test. ARCH-LM is the Lagrange Multiplier test for ARCH effects (Engle, 1982).

Most importantly, Table 7 result shows the mixed evidence in the case of spillover effect. The findings of underlying commodities of metals Bivariate EGARCH model depicts that the bidirectional spillover exists between spot and futures markets in the case of five Metal commodities, viz. Aluminium, Nickel, Lead, Steel Flat and Zinc. The analysis also confirms the unidirectional spillover from spot market price to futures market price and futures market price to spot market price in the case of Iron Ore, Sponge Iron and Tin and Copper and Thermal Coal, respectively. To check the robustness of Bivariate EGARCH estimates for the respective commodities of metal sector, the ARCH-LM (Engle, 1982) test was employed to test the absence of any further ARCH effects. As can be seen in Table 7, the ARCH-LM statistics indicate that no serial dependence persists left in squared residuals. Hence, the results suggest that Bivariate EGARCH model was reasonably well specified and most appropriate model to capture the ARCH (time-varying volatility) effects in the time series analyzed for respective commodities that belong to metal.

Conclusion

Since 2002 the commodities futures market in India has experienced an unexpected boom in terms of modern exchanges, number of commodities allowed for derivatives trading as well as the value of futures trading. The true potential and usefulness of commodity derivatives market is yet to be achieved in further developing the commodity market in India. Commodity derivatives markets play an important role in the efficient price discovery process. The Indian commodity derivative market can play a crucial role provided regulatory policies are flexible and market participants are aware about their existence. With SEBI as the new independent regulator with experience of successfully regulating the financial market in India, the commodity derivatives market is expected to achieve greater heights in the years to come. Commodity Futures Market plays an important role in price discovery, the information on which helps the producers to plan their activities on production, processing, storage, and marketing of commodities. The research study is limited for commodity markets, especially on metal sector and India in particular. The empirical results confirm the price discovery between futures and spot prices, indicating strong information transmission from futures markets to spot markets in the case of majority of metal commodities. The feedback spillover effect exists between spot and futures market prices in majority of the underlying commodities that belongs to Metals. Besides, the study results suggest that the volatility spillover effects are found to be quite strong between spot and futures markets in the case of majority Metal commodities.

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