

Volatility Spillover in the Indian Commodity Market : A Comparative Assessment of Various Commodity Segments

Sonia¹

Karam Pal Narwal²

Abstract

Purpose : The present study concentrated on analyzing the volatility spillover effect between spot and futures returns of eight commodities traded on India's multi-commodity exchange (MCX). This study intended to compare the volatility spillover effect within spot and futures returns of four commodity segments, such as metal, energy, bullion, and agriculture, to determine whether the volatility spillover effect was similar in all categories or not.

Methodology : The sample of the study included two commodities from each category. The closing spot and futures prices were extracted from MCX India Ltd.'s authenticated sources for the period spanning from January 2009 – March 2020 for all sampled commodities except cotton (for cotton, September 2011 – March 2020). The present study used the EGARCH model to study the volatility transmission between markets.

Findings : The outcomes of the study indicated that there existed a volatility spillover effect in all sampled commodities. Also, the outcomes revealed that the volatility spillover effect in all segments was quite different from each other.

Practical Implications : A comparative assessment of the volatility spillover mechanism existing between the two markets of various groups of commodities will be advantageous for investors, traders, and portfolio managers in selecting the most profitable group of commodities for investment, trading, and portfolio optimization.

Originality/Value : In India, there have been very few empirical studies that compare the comparative aspects of spillover effects across various commodity segments.

Keywords : Volatility spillover, agricultural commodities, metal commodities, energy commodities, bullion commodities, EGARCH

JEL Classification Codes : C10, G13, G17

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In the past, commodity markets were basically developed to protect the farmers from the price risk arising due to the time gap between crop sowing and crop harvesting. But, nowadays, commodity markets have emerged as separate asset classes for investment worldwide. A commodity derivative market is multifarious in a developing country such as India (Irfan & Hooda, 2017). That's why the commodity market has been receiving considerable attention from researchers globally. Most of the previous studies related to the commodity market focused on the price discovery aspect. The essence of the price discovery process is determined by whether new

¹ *Research Scholar (Corresponding Author)*, Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar - 125 001, Haryana. (Email : soniagarg569@gmail.com) ; ORCID iD : <https://orcid.org/0000-0003-4601-9527>

² *Professor*, Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar - 125 001, Haryana. (Email : karampalhsb@gmail.com) ; ORCID iD : <https://orcid.org/0000-0002-8537-2158>

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information is first reflected in changes in spot prices or changes in futures prices (Srinivasan & Ibrahim, 2012). Apart from price discovery, volatility, which explains the variations in returns (Dikshita & Singh, 2019), is also a significant source of information. Ross (1989) also argued that the rate of flow of information is directly related to volatility. The increase in the flow of information in a particular market causes an increase in volatility which further initiates the arbitrage process leading to a spillover of volatility in the other related markets as well (Malhotra & Sharma, 2016). Thus, the investigation of volatility spillover between two markets, the process through which the volatility of one market impacts that of another market, furthers the understanding of information dissemination in financial markets.

Further, if there is a spillover of volatility between the markets, then the market which transmits the volatility may be employed by the market agents to cover the risk exposure they face (Kavussanos & Visvikis, 2004). The knowledge of the relationship between the two markets' volatilities is vital as it will disclose whether spot market reactions cause spillover into futures markets or the other way around. Further, very few studies have compared the volatility spillover process of various categories of commodities. There is hardly any study that compares the volatility spillover process of various categories such as metal, energy, bullion, and agriculture. Therefore, the current study attempts to compare the various categories of commodities in terms of the volatility spillover mechanism.

Literature Review

The present study tends to compare various commodity segments in terms of the volatility spillover process, therefore, the reviewed literature has been categorized into the following:

Studies Related to Metal Commodities

Barreto and Ramesh (2018) examined the volatility spillover mechanism of 10 metal commodities and revealed that bidirectional volatility spillover existed for most of the sampled commodities. Behera (2016) also found similar results. Kim and Lim (2019) examined the volatility spillover effect in China's futures and spot market of steel commodities and revealed that volatility spillover existed from commodity futures to the spot market in four commodities out of seven. Sonia and Narwal (2021) investigated the volatility spillover in Indian commodity base metal markets and showed the existence of a spillover effect from the futures to the spot for three out of five commodities.

Studies Related to Energy Commodities

Seth and Sidhu (2021) studied the volatility spillover in the Indian energy market using the GJR-GARCH model and demonstrated the dominance of volatility spillover from futures to spot.

Studies Related to Bullion Commodities

Thenmozhi and Priya (2008) studied the volatility spillovers in the spot and futures markets for silver, gold, and crude oil. They also showed that volatility spillover from spot to futures was dominant for gold and crude oil, and for silver, the volatility spillover from futures to spot commodity markets was dominant. Srinivasan and Ibrahim (2012) investigated the volatility spillover in the gold market by administering a bivariate ECM-EGARCH (1,1) model and determined that the volatility spillover took place from spot to futures markets. Mathew and Sulphey

(2019) also explored the volatility spillover in the gold futures market and indicated that bi-directional volatility spillover existed between the spot and futures markets of gold.

Studies Related to Agricultural Commodities

Chauhan et al. (2013) employed GARCH (1, 1) model to investigate the volatility spillovers in agricultural commodity markets and indicated that volatility spillovers took place from futures to spot for guar seed and from spot to futures for chana. Arora and Chander (2016) studied the volatility spillover mechanism for four commodities by employing the EGARCH model and demonstrated the volatility spillover from commodity futures to the spot market. Gupta and Varma (2016) investigated the volatility spillover in rubber and demonstrated that bidirectional volatility spillover existed in the futures-spot market of rubber. Babshetti and Basanna (2018) analyzed the presence of convergence between two price series (spot and futures) of agricultural commodities to assess the scope of the arbitrage process between prices and revealed the presence of scope for arbitrage in these series. Kaura et al. (2019) also found similar results. Manogna and Misra (2020) investigated the volatility spillover effect by applying a combination of the VECM and EGARCH model and concluded that futures markets dominated the volatility spillover in six commodities out of nine commodities.

Studies Related to Various Commodity Groups

Kaura et al. (2018) analyzed the volatility spillover process by taking a sample of 13 commodities traded on MCX, and demonstrated that volatility spillover from futures to spot was higher for all sampled commodities. Mathew et al. (2022) investigated the volatility spillover considering a sample of 10 commodities and demonstrated that for the majority of the commodities, volatility spilled over from futures to the spot market. Rout et al. (2019) examined the volatility spillover mechanism by utilizing the generalized impulse response function (IRF) and showed that agriculture and metal commodities both had bidirectional volatility spillover. However, the magnitude of volatility spillover was headed for metal commodity spot to futures and agricultural commodity futures to spot.

Research Problem and Objective of the Study

After reviewing the previous literature, it has been observed that a handful of studies have been conducted with regard to the Indian commodity market, which explored the volatility spillover mechanism in futures-spot commodity markets. The majority took a sample of either metal or energy, bullion, or agricultural commodities. Few of them, on the other hand, employed a mix of commodities belonging to various categories of commodities. There is hardly any study which compares the volatility spillover process of various categories such as metal, energy, bullion, and agriculture. All the commodities being traded are not similar in nature. For example, non-agricultural commodities (metal, bullion, and energy) are durable and thus storable, although this is not the case for most agricultural commodities. The majority of agricultural commodities are subject to seasonal fluctuations; whereas, most non-agricultural commodities are not. Since the sample commodities possess different features, their volatility spillover mechanism may also differ in accordance with various groups of commodities.

Therefore, this study aims to compare the volatility spillover aspect of various commodity categories traded in India to know whether the volatility spillover process is the same for the whole commodity market or varies according to various commodity groups such as metal, energy, bullion, and agriculture. Thus, in order to fulfill the research objective, the following research hypotheses are framed for this study:

- ⇒ **H01** : There is no significant volatility spillover between futures and spot markets of sampled commodities.
- ⇒ **H02** : There is no similarity in the direction of volatility spillover between futures and spot markets across all commodity categories.

Research Methodology

Data Set and Data Sources

The current study is empirical in nature and analyzes a sample of eight commodities that are heavily traded on the MCX. These commodities are categorized into four segments. Lead and nickel represent the metal segment, natural gas and crude oil represent the energy sector, gold and silver represent the bullion segment, and lastly, cotton and mentha oil represent the agriculture sector. The current study utilizes secondary data comprising of daily spot and futures returns, which are estimated from closing spot and futures prices of near-month contracts of the considered commodities. The closing spot and futures prices were extracted from the MCX official website for the time period from January 2009 – March 2020 for all sampled commodities except cotton, where prices were obtained from September 2011 – March 2020. Data were analyzed with the help of MS Excel, MS Word, and E-Views 10 econometric software package.

Unit Root Test

Before the utilization of any econometric model, it is imperative to test the stationarity of the price series of all sampled commodities. ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) tests are used to check stationarity. The following ADF and PP have been used in this study.

The ADF model tests unit root as follows:

$$\Delta Y_t = \mu + \delta Y_{t-1} + \sum_{i=1}^k \beta_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

The PP model tests unit root as follows :

$$\Delta Y_t = \pi Y_{t-1} + \beta_i D_{t-i} + \varepsilon_t \quad (2)$$

The EGARCH Model

Nelson's (1991) EGARCH model is used in a recent study to investigate volatility spillover between futures and spot markets. Although the GARCH model is more popular in analyzing the volatility procedure, however, recent studies like Nirmala and Deepthy (2018), Manogna and Mishra (2020), Rout et al. (2021), Sonia and Narwal (2021), Joshi (2021), and Kumar et al. (2022) provided evidence that the EGARCH model elucidates the volatility dynamics more accurately. The basic GARCH model captures a symmetric effect only by putting a negative condition variation; whereas, the EGARCH model captures both symmetric and asymmetric effects. In other words, the EGARCH model has the advantage of incorporating the negative and positive conditional variance, which means seeing the effect of bad news and good news on volatility. Further, the EGARCH model expresses conditional variance in the logarithmic form; as a result, no estimation constraints are required to avoid negative variance (Nelson, 1991).

The study follows the step-by-step procedure for measuring volatility spillover between markets. First, the returns of all sampled commodities are computed through natural logged and ratio of present-day price and previous-day price, that is:

$$R_t = \ln(SP_t / SP_{t-1}) \quad (3)$$

$$R_t = \ln(FP_t / FP_{t-1}) \quad (4)$$

where,

R_t represents the return of the spot and futures price series. SP_t and FP_t represent the current-day closing spot and futures prices. SP_{t-1} and FP_{t-1} represent the previous day spot and futures price series.

In the second step, the presence of the heteroskedasticity in the residuals of the regression equation of regressing the first lag of respective series, that is, spot return (-1) or futures return (-1) to the spot return or futures return has been detected by utilizing the ARCH-LM test (Engle, 1982) and checks the probability of chi-square. The ARCH LM test tests the null hypothesis of no ARCH effects in both return series of sampled commodities against the alternative hypothesis of ARCH effects in both return series of the sampled commodities. A significant chi-square value leads to the rejection of the null hypothesis and evidences the presence of the ARCH effect in the underlying variable. After confirming the presence of heteroskedasticity in the residuals, the choice to use the EGARCH model is made. In the third step, volatility spillover between futures and spot is studied in two ways. First, we create a volatility residual series using a specific EGARCH model for both markets. After that, the created volatility residual series is taken as a proxy of shock emanating from the other market. For studying the volatility spillover from futures to spot, the volatility residual series of the futures market is used as shock emanating to spot market and vice-versa. Thus, the EGARCH model is conducted for each market separately in order to study the volatility spillover between the markets.

The mean equation used for the futures market is :

$$FR_t = \beta_0 + \beta_1 FR_{t-1} + \varepsilon_t \quad (5)$$

The mean equation used for the spot market is :

$$SR_t = \beta_0 + \beta_1 SR_{t-1} + \varepsilon_t \quad (6)$$

where,

FR_t and SR_t are the returns of futures prices and spot prices at time t , β_0 is intercept, β_1 is the coefficient of futures returns and spot returns which estimate the impacts of the previous day's return on the current day's return, and ε_t is the error term.

This model's variance equation is given by :

The EGARCH (1,1) equation for futures market is presented as follows:

$$\ln(\sigma_{f,t}^2) = \omega_f + \delta_f \ln(\sigma_{f,t-1}^2) + \Psi_f \left| \frac{\varepsilon_{f,t-1}}{\sigma_{f,t-1}} - \sqrt{2/\pi} \right| + \gamma_f \ln \frac{\varepsilon_{f,t-1}}{\sigma_{f,t-1}} + \lambda_f (\text{resid}(SR)) \quad (7)$$

The EGARCH (1, 1) equation for the spot market is presented as follows :

$$\ln(\sigma_{s,t}^2) = \omega_s + \delta_s \ln(\sigma_{s,t-1}^2) + \Psi_s \left| \frac{\varepsilon_{s,t-1}}{\sigma_{s,t-1}} - \sqrt{2/\pi} \right| + \gamma_s \ln \frac{\varepsilon_{s,t-1}}{\sigma_{s,t-1}} + \lambda_s (\text{resid}(FR)) \quad (8)$$

where,

$\ln(\sigma_{f,t}^2)$ and $(\sigma_{s,t}^2)$ depict conditional time-varying variances of spot and futures returns. ω represents the constant, δ measures the persistence of volatility, Ψ measures the reaction of volatility to news, and γ measures the asymmetric effect of volatility (leverage effect). The coefficients of λ_f and λ_s measure the volatility spillover from spot to futures and futures to spot.

Analysis and Results

Descriptive Statistics

Table 1 displays the descriptive statistics of the return series of all sampled commodities. The results of the analysis reveal that the mean values of all return series are near to zero. For all commodities, the standard deviation values, which refer to the variation from the mean, are higher than the mean values. The crude oil spot returns show a higher standard deviation of 0.03223, followed by futures returns of crude oil (0.03094) and spot returns of natural gas (0.02880). The value of skewness is very high in case of all sampled commodities. It is negative for spot and futures returns of nickel, silver; futures returns of mentha oil; and spot returns of crude oil and cotton. It is positive for spot and futures returns of lead, natural gas, and gold ; futures returns of crude oil, cotton; and spot returns of mentha oil. The kurtosis values of all return series show that the series has a leptokurtic distribution, which evidences that the selected commodities may generate either extremely high or extremely low returns. The

Table 1. Descriptive Statistics

Return Series	Mean	Median	Maximum	Minimum	Std.Dev	Skewness	Kurtosis	J – B	Probability
Nickel									
Futures	0.00020	0.00025	0.09700	-0.14685	0.01762	-0.29101	7.15215	2164.4240	0.0000
Spot	0.00024	0.00000	0.17109	-0.15896	0.01867	-0.23260	10.62410	7183.5120	0.0000
Lead									
Futures	0.00033	0.00043	0.18078	-0.138694	0.01646	0.24953	12.40808	11139.5100	0.0000
Spot	0.00037	0.00000	0.18913	-0.114564	0.01712	0.53408	11.53973	9295.5290	0.0000
Natural Gas									
Futures	-0.00027	0.00000	0.18867	-0.16200	0.02746	0.36706	7.30427	2391.9410	0.0000
Spot	-0.00027	0.00000	0.19212	-0.17980	0.02880	0.29236	7.10206	2153.9680	0.0000
Crude Oil									
Futures	0.00023	4.56E-05	0.21256	-0.192852	0.03094	0.28412	5.80564	1008.2670	0.0000
Spot	0.00022	6.20E-04	0.16250	-0.175425	0.03223	-0.02712	5.28296	641.6408	0.0000
Gold									
Futures	0.00035	0.00036	0.12244	-0.08560	0.00927	0.65604	19.72880	34574.9900	0.0000
Spot	0.00036	0.00000	0.06751	-0.07224	0.00819	0.11293	10.54377	6996.5220	0.0000
Silver									
Futures	0.00033	0.00039	0.09389	-0.175353	0.01532	-0.93895	16.90995	24265.4700	0.0000
Spot	0.00038	0.00034	0.10197	-0.176154	0.01445	-1.197789	20.62166	38531.2100	0.0000
Cotton									
Futures	0.0000	0.0000	0.0780	-0.1040	0.0120	0.0240	10.8650	5686.6030	0.0000
Spot	0.0000	0.0000	0.0430	-0.0440	0.0070	-0.1600	9.2350	3583.2400	0.0000
Mentha Oil									
Futures	0.0000	0.0000	0.1930	-0.2040	0.0270	-0.0300	13.4710	12033.4800	0.0000
Spot	0.0000	0.0000	0.1460	-0.1450	0.0170	0.2100	15.0520	15959.9400	0.0000

Note. J – B stands for Jarque-Bera.

Table 2. Outcomes of Unit Root Tests

		ADF(at level)		PP(at level)	
Commodity	Returns	Coefficients	p-value	Coefficients	p-value
Metal Commodities					
Nickel	Futures	−56.551**	0.0001	−56.559**	0.0001
	Spot	−58.389**	0.0001	−58.413**	0.0001
Lead	Futures	−55.281**	0.0001	−55.355**	0.0001
	Spot	−55.941**	0.0001	−56.017**	0.0001
Energy Commodities					
Natural Gas	Futures	−56.191**	0.0001	−56.268**	0.0001
	Spot	−24.016**	0.0000	−740.740**	0.0001
Crude Oil	Futures	−55.471**	0.0001	−55.516**	0.0001
	Spot	−61.963**	0.0001	−61.528**	0.0001
Bullion Commodities					
Gold	Futures	−54.592**	0.0001	−54.602**	0.0001
	Spot	−53.696**	0.0001	−53.796**	0.0001
Silver	Futures	−56.584**	0.0001	−56.558**	0.0001
	Spot	−54.450**	0.0001	−54.450**	0.0001
Agricultural Commodities					
Cotton	Futures	−50.150**	0.0001	−50.150**	0.0001
	Spot	−38.484**	0.0000	−41.893**	0.0000
Mentha Oil	Futures	−59.834**	0.0000	−59.488**	0.0001
	Spot	−21.716**	0.0000	−48.491**	0.0001

Note. ** indicates significance at 5%.

values of the Jarque-Bera test show that all the returns series are non-normal, as evidenced by the significant probability values of all return series. This shows the indications of the presence of volatility.

Unit Root Test

The outcomes of the unit root tests have been reported in Table 2. The ADF and PP test results exhibit that all spot and futures return series of the sampled commodities are stationary at a 5% significant level.

ARCH Test

The outcomes of the ARCH test are depicted in Table 3. The ARCH test results indicate that the null hypothesis of no ARCH effects is rejected for both spot and futures markets of all sampled commodities at the 5% significance level. Thus, the ARCH effect exists in both spot and futures returns of the sampled commodities. Therefore, the EGARCH model can be utilized.

The EGARCH Model

Volatility spillover between returns has been studied using the EGARCH (1, 1) model. The spillover of volatility

Table 3. Outcomes of the ARCH Test

Commodities	Constant	AR(1)	ARCH Test
Metal Commodities			
Nickel			
Futures	0.000182(0.5731)	-0.027262(0.1377)	40.47056**(0.0000)
Spot	0.00019(0.5742)	-0.044824(0.0134)	46.50257**(0.0000)
Lead			
Futures	0.000305(0.3075)	0.007885(0.6648)	13.44945**(0.0012)
Spot	0.00035(0.260)	-0.025033(0.1672)	10.96492**(0.0042)
Energy Commodities			
Natural Gas			
Futures	-0.000289(0.5639)	-0.009384(0.6066)	68.66346**(0.0000)
Spot	-0.000287(0.584)	-0.05952**(0.0011)	70.87205**(0.0000)
Crude Oil			
Futures	0.000278(0.6197)	-0.180084**(0.0000)	235.5808**(0.0000)
Spot	0.000292(0.6145)	-0.213277**(0.0000)	243.5886**(0.0000)
Bullion Commodities			
Gold			
Futures	0.000381**(0.0234)	-0.011955(0.5123)	19.17143**(0.0001)
Spot	0.000385**(0.0109)	-0.011791(0.5183)	200.5636**(0.0000)
Silver			
Futures	0.000354(0.2070)	-0.091607**(0.0000)	191.6576**(0.0000)
Spot	0.000421(0.1122)	-0.04197**(0.0225)	254.0879**(0.0000)
Agricultural Commodities			
Cotton			
Futures	-0.0000416(0.8670)	-0.066415**(0.0018)	18.44635**(0.0001)
Spot	-0.0000116(0.9374)	0.195886**(0.0000)	36.612**(0.0000)
Mentha Oil			
Futures	0.000362(0.4914)	-0.152718**(0.0000)	129.3719**(0.0000)
Spot	0.000271(0.4015)	0.084552**(0.0000)	144.5989**(0.0000)

Note. ** indicates significance at 5%.

between spot and futures return as well as between futures and spot return for each commodity has been studied separately. Table 4 indicates the outcomes of the EGARCH (1, 1) model. The coefficients λ_f and λ_s measure the volatility spillover from spot to futures and futures to spot, respectively. When it comes to metal commodities, the coefficients of λ_f are significant, indicating unidirectional volatility from spot returns to futures returns. For energy and bullion commodities, the coefficients of both λ_f and λ_s are significant, which show the presence of bidirectional volatility spillover between futures and spot returns. However, based on the magnitude of the coefficients, spot returns lead to futures returns in the case of energy commodities. In the case of bullion commodities, futures returns lead to spot returns. For agricultural commodities, the coefficients of λ_s are significant, indicating that unidirectional volatility spillover from futures to spot returns is present.

Thus, the results help to conclude that significant volatility spillover exists (in either direction) between the two markets (spot and futures) for all commodities sampled. This leads to the rejection of the null hypothesis (H01) that there is no significant volatility spillover between futures and spot markets of the sampled commodities.

The coefficients δ_f and δ_s capture the degree of volatility persistence. The degree of volatility persistence implies the time volatility takes to decay subsequent to a market shock. The values of δ_f and δ_s are significant in the case of all commodities, which implies that when an information shock occurs, volatility tends to persist for short periods in both futures and spot markets of the respective commodities.

The coefficients γ_f and γ_s measures the leverage effect, which shows that negative news (or bad news) has more influence on market volatility than positive news (or good news). If the coefficients γ_f and γ_s are negative and statistically significant, then the leverage effect exists in the market, and the model is asymmetric (Ranganath et al., 2017). This condition is not satisfied in spot and futures markets for all commodities sampled, as shown in Table 4. Thus, it can be concluded that no leverage effect exists in these commodities.

Table 4. Results of EGARCH(1,1) Model

Commodity	Constant	AR(1)	ω	δ	Ψ	Γ	λ	Q^2 -Stat	ARCH Test
Metal Commodities									
Nickel									
Futures	0.0005** (0.0412)	-0.022 (0.1913)	-0.191** (0.0000)	0.083** (0.0000)	0.0613 (0.0005)	0.984** (0.000)	-0.05** (0.0017)	At lag 20 = -0.017 (0.4630)	At lag2 = 5.411 (0.0668)
Spot	1.27E-10 (1.0000)	3.67E-09 (1.0000)	-0.108** (0.0001)	6.00E-02** (0.0001)	3.11E-02 (0.1118)	0.99** (0.000)	-0.008 (0.6265)	At lag 20 = 0.009 (0.885)	At lag2 = 2.261 (0.3229)
Lead									
Futures	4.00E-05 (0.8525)	-0.0041 (0.7942)	-0.159** (0.0000)	0.087** (0.0000)	-0.057** (0.0000)	0.989** (0.000)	0.067** (0.0000)	At lag 20 = -0.003 (0.9970)	At lag2 = 0.955 (0.6202)
Spot	-1.81E-08 (0.9999)	3.10E-07 (1.0000)	-0.056** (0.0017)	3.75E-02** (0.0020)	-0.0209 (0.1201)	0.996** (0.000)	0.0209 (0.0804)	At lag 20 = -0.017 (0.9980)	At lag2 = 0.355 (0.8375)
Energy Commodities									
Natural Gas									
Futures	-0.0005 (0.1621)	-0.0021 (0.8999)	-0.249** (0.0000)	0.148** (0.0000)	-0.065** (0.0006)	0.98** (0.000)	0.098** (0.0000)	At lag 20 = -0.018 (0.4850)	At lag2 = 4.879 (0.0872)
Spot	5.90E-09 (1.0000)	-2.72E-07 (1.0000)	-0.199** (0.0001)	0.135** (0.0000)	-0.0123 (0.5619)	0.985** (0.000)	0.037** (0.0337)	At lag 20 = 0.008 (0.7040)	At lag2 = 0.856 (0.6517)
Crude Oil									
Futures	-0.002** (0.0033)	-0.190** (0.0000)	-0.362** (0.0000)	0.172** (0.0000)	-0.138** (0.0000)	0.968** (0.000)	0.072** (0.0001)	At lag 4 = -0.009 (0.8400)	At lag2 = 1.042 (0.5940)
Spot	0.0003 (0.5925)	-0.208** (0.0000)	-0.263** (0.0000)	0.160** (0.0000)	-0.042** (0.0249)	0.981** (0.000)	-0.04** (0.0029)	At lag 4 = -0.006 (0.662)	At lag2 = 2.004 (0.3672)
Bullion Commodities									
Gold									
Futures	0.0003** (0.0016)	-0.0197 (0.2015)	-0.592** (0.0000)	0.206** (0.0000)	-0.0247 (0.2279)	0.954** (0.000)	0.052** (0.0002)	At lag 20 = -0.006 (0.9760)	At lag2 = 3.492 (0.1744)
Spot	0.0002**	-0.0093	-1.101**	0.297**	-0.0266	0.909**	0.056**	At lag 20 = -0.005	At lag2 = 2.102

	(0.0436)	(0.5657)	(0.0000)	(0.0000)	(0.2413)	(0.000)	(0.0000)	(0.0940)	(0.3495)
Silver									
Futures	0.0003**	-0.043**	-0.703**	0.243**	0.058**	0.938**	-0.03**	At lag 20 = -0.009	At lag5 = 8.295
	(0.0480)	(0.004)	(0.0000)	(0.0000)	(0.0230)	(0.000)	(0.0457)	(0.4300)	(0.1407)
Spot	0.0004**	-0.0067	-0.421**	0.193**	0.041**	0.968**	-0.04**	At lag 20 = -0.026	At lag5 = 10.75
	(0.0076)	(0.6645)	(0.0000)	(0.0000)	(0.0219)	(0.000)	(0.0016)	(0.2120)	(0.0565)
Agricultural Commodities									
Cotton									
Futures	-0.0002	-0.039**	-9.118**	0.432**	-0.179**	0.0243	-0.0088	At lag20 = 0.007	At lag2 = 0.2880
	(0.3925)	(0.045)	(0.0000)	(0.0000)	(0.0000)	(0.846)	(0.7120)	(0.6450)	(0.8659)
Spot	-4.00E-05	0.133**	-0.547**	0.198**	0.0018	0.959**	0.048**	At lag20 = 0.009	At lag2 = 1.1624
	(0.5743)	(0.0000)	(0.0000)	(0.0000)	(0.9289)	(0.000)	(0.0083)	(0.9830)	(0.5592)
Mentha Oil									
Futures	-3.76E-13	1.32E-11	-4.209**	0.524**	0.114**	0.485**	0.0309	At lag20 = 0.027	At lag2 = 2.8977
	(1.0000)	(1.0000)	(0.0000)	(0.0000)	(0.0175)	(0.000)	(0.1589)	(0.8410)	(0.2348)
Spot	2.54E-11	0.0006	-0.512**	0.328**	0.0008	0.968**	0.074**	At lag20 = -0.004	At lag2 = 0.9172
	(1.0000)	(0.9698)	(0.0000)	(0.0000)	(0.9727)	(0.000)	(0.0001)	(0.9840)	(0.6322)

Note. ** indicates significance at the 5%.

Table 5. Comparison of the Results of Different Categories of Commodities

Metal	Energy	Bullion	Agricultural
Unidirectional volatility spillover from commodity spot returns to futures returns is significant.	Bidirectional volatility spillover exists between commodity futures and spot returns, but the volatility spillover effect from spot to futures returns is very high in magnitude.	Bidirectional volatility spillover exists between commodity futures and spot returns, but the volatility spillover effect from futures to spot returns is quite high in magnitude.	Unidirectional volatility spillover from commodity futures to spot returns is significant.

To check the robustness of the results of the present study, residual diagnostics tests such as the correlogram test and ARCH LM test are utilized to test the existence of autocorrelation and heteroskedasticity in the residuals of the specified regression equation. The outcomes of the correlogram test and ARCH LM test confirm the absence of autocorrelation and heteroskedasticity problem in the residuals. Table 5 compares the results of different categories of commodities and depicts that the spillover of volatility is different in each of the categories. Therefore, we fail to reject the null hypothesis (H02) that there is no similarity in the direction of volatility spillover between futures and spot markets across all commodity categories.

Conclusion

The current study analyzes the volatility spillover effect in Indian commodity spot and futures markets of various commodities traded on MCX by utilizing the EGARCH model. This study also compares the volatility spillover process of various groups of commodities traded on MCX considering the period from January 2009 – March 2020, except cotton (for cotton, September 2011 – March 2020). The study results show that volatility spillover exists in spot-futures markets of all studied commodities. Further, the results show that the spillover

effect in all categories is quite different from each other. Metal commodities exhibit unidirectional volatility spillover from spot to futures. The results of metal commodities are in line with the previous studies (Rout et al., 2019). Bidirectional volatility spillover effect is found to exist, but the volatility spillover effect from spot to futures returns is very high in magnitude. The results of energy commodities are in collaboration with earlier studies (Thenmozhi & Priya, 2008). The bidirectional volatility spillover effect is exhibited in bullion segment commodities with the dominance of the futures market. The outcomes of bullion commodities are consistent with the prior studies (Shihabudheen & Padhi, 2010). Finally, unidirectional volatility spillover is found to exist for futures to spot market in agriculture commodities.

Policy Implications

The theoretical application of this study is an attempt to compare the volatility spillover effect of various commodity segments (such as metal, energy, bullion, and agriculture). In India, there have been very few empirical studies that compare the comparative aspects of spillover effects across various commodity segments. Evidence of volatility spillover interlinkages between the two markets for various commodity groups, including metal, energy, bullion, and agriculture, can inform traders and investors about the nature of volatility spillovers between spot and futures markets for various commodity groups. Portfolio managers can estimate the diversification benefits that exist between two markets by understanding the volatility spillover between the markets of various commodities. Furthermore, understanding volatility spillover between two markets aids policymakers in developing appropriate strategies and policies to mitigate high volatility during excessive price movements in the underlying markets.

Limitations of the Study and Future Research Directions

Although volatility spillover can be transmitted through many macroeconomic factors like stock market prices, exchange rate, money supply, etc., but the interconnection between spot and futures markets is considered as the only channel of volatility spillover in the present study. This research can be extended by considering the influence of macroeconomic factors to test the volatility spillover effect. Another limitation is that the current study has administered only the EGARCH model. Further research can be conducted by applying more advanced methodology, for example, MGARCH, PARCH, TARCH, and Copula-GARCH, etc. This study is based only on MCX. Therefore, there is scope of doing such research for other National Commodity Exchanges like NCDEX, ICEX, etc. Another prominent area of research is using high frequency data and including more commodities in the sample size.

Authors' Contribution

The idea of writing this paper was given by Prof. Karam Pal Narwal, and this whole research work has been done under the supervision of Prof. Karam Pal Narwal. Sonia did the collection of the available literature, analysis, and interpretation.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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About the Authors

Sonia is currently a Research Scholar under the supervision of Professor Karam Pal Narwal at Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar, Haryana. She is pursuing research in the area of commodity derivatives.

Dr. Karam Pal Narwal is currently working as a Professor at the Haryana School of Business, Guru Jambheshwar University, Hisar, Haryana. He has published more than 150 research papers in different journals.