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ASYMMETRIC VOLATILITY SPILLOVERS IN INDIAN COMMODITY MARKET

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ABSTRACT

The present study examines price discovery and volatility spillovers in spot-future prices of Indian commodity markets by using cointegration (Johansen, 1991), VECM and the bivariate EGARCH (Nelson, 1991) model. Impulse response and variance decomposition has been used to study nature of volatality transmission in spot and future prices. Data from April 2008 to March 2018 has been collected for the select commodities (Soya Oil, Chana, Silver, Lead, and Cruid Oil) from MCX and NCDEX. VECM-GARCH model results show that volatility spill over from futures is dominant in all the commodities. Volatility persistence is significance in all the select commodities and high persistence of volatility is observed in all the spot and future prices of select commodities except in spot volatility of Lead and futures volatility of Soya oil and Chana. In case of Chana spot and Lead spot volatilities, positive shock give to more volatility than negative shock where as in Chana futures and Lead futures volatility negative information leads to more volatility than positive news. In Soya Oil and Cruid oil both the spot and futures volatilities are more sensitive to bad news than good news

Keywords: *Unit root, Cointegraion, Causality, Volatility Spillover, Volatility Clustering, Asymmetry, EGARCH, Leverage Effect.*
JEL Classification *G13, G14, C22.*

I. INTRODUCTION

Gradual evolution of commodity markets in India has been of great significance for both the country's general economic distribution and its linkages with financial sector. The success of spot and futures markets in performing the stabilizing function explains whether they are efficient In a perfectly efficient market, it is impossible for an investor to outperform the market, since relevant information is almost freely available to all participants and is rapidly reflected in security prices (Fama, 1965, 1970). This relationship between spot and future market is investigated because in a perfect efficiently organized futures and markets, rational investors are indifferent among trading in either market, as the new information disseminates in both markets at the same time and the prices are fairly and accurately valued.

Commodities are regarded as separate assets in the domain of all assets class. Existence of a vibrant, active and liquid commodity market is considered as a healthy sign for the development of an economy. In the context of an emerging market like India, the growth of capital and commodity future market would depend on the effectiveness of derivatives in managing risk. Price discovery and risk management through the existence of futures exchanges that a lot of businesses and services are able to function smoothly.

The efficiency of the market depends on how new information is impounded simultaneously into cash and futures markets. 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). 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.

The risk management which involves the volatility in the prices is to be addressed to know how stable the market performs. Volatility refers to the spread of all likely outcomes of an uncertain variable. An increase in market volatility brings a large price change in the advances or declines. Investors interpret a raise in market volatility and increase in the risk of investments and shift their funds to less risky assets (Pandin and Jeyanthi,2009).

The volatility spillovers between the two markets have to be understood as how the information destabilizes and how it moves from one market to another market. The persistence of volatility or existence of volatility clusters is also an aspect of interest as the more persistence of volatility in markets is considered as to have long term impact of news and may lead to depression. The impact of positive news and negative news impact on the markets too has to be observed as they give whether the market is asymmetric or there is more volatility towards good or bad information.

II. REVIEW OF RELATED LITERATURE

The relationship and causality between spot and future prices in the commodities is thoroughly discussed in the literature. Futures markets generally dominate spot markets in registering and transmitting information. Henandez and Torero(2010) and Wang and Zhang (2005).Other studies, however, have undermined these results and find that spot prices lead futures prices Mohan and Love (2004), Srinivasan, Malabika (2009). Future prices have stronger ability to predict the spot prices of but bidirectional relationship is also observed in some studies. Jabir and Kritiob(2011), and Lee and Zeng (2011).

Sehal et, al. (2013) observed Volatility spill-over is confirmed for only three out of eight commodities and none of the indices. Studies on Indian commodity markets Malik(2009), Shihabudheen et, al.(2010), and Chauhan(2013), show futures price dominance in the volatility spillover on spot prices in various commodities. Manthu Kukar (2014) observed that the volatility spillovers from future to the spot market are dominant in the case of Energy COMDEX indices while Agri spot index acts as a source of volatility towards the agri-futures index. Gupta et, al.(2013) observed that in Chana and Gruseed spot prices have volatality spillover on future prices but in Gold, Silver and Soya oil futures dominance in volatality spillover is observed; differences in the spillover effect in three exchanges(MCX,NCDEX and NMCE)is also evident from the study. From the study by Srinivasan (2012) indicates that although bidirectional volatility spillover persists, the volatility spillovers from spot to the futures market are dominant in case of all MCX commodity indexes.

Booth et al.(1997) examined the scandavian stock markets and found that the volatility transmission was asymmetric, spillovers being more pronounced for bad than good news. In Indian stock market also the same tendency observed as negative shocks have more sensitivity than positive news is observed from the studies of Ramanarayanan et, al.(2011) and Mallikarjunappa et, al.(2010). There are few studies on volatility spillover along with the asymmetric impact of bad news and good news on volatility with reference to Indian commodity markets.

Many studies cover an individual commodity or the commodity indices which may not represent the true picture of entire market. There is need to study various classes of commodities and compare the spillover effects along with the impact of positive and negative shocks. To fill this gap, an attempt has been made to study the spillover effect and asymmetry in Indian spot-futures volatilities in Indian commodity markets.

III. DATA SPECIFICATION

Study period is of ten years from April 20098 to March 2018 has been considered in Silver, Lead and Crude oil. December 2008 to July 2016 in Chana and December 2008 to March 2018 for Soya oil is considered as the study period as there were trade suspensions before December 2008 and after July 2016. Data required for the present study are collected from official websites of Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange(NCDEX). Five commodities have been chosen for the study inclusive of Metal, Agricultural and Energy products. Silver and lead are chosen from the metal products as they have highest trading volume from precious metal and base metal segments respectively and data is collected from MCX as the maximum trade in metal happens in MCX only. Soya oil and Channa have been chosen as they have higher trading volume from oil products and cereals respectively and data has been collected from NCDEX as it is specialised in agricultural commodities. Crude oil has been chosen from Energy product as it has the maximum trading volume and the data is collected from MCX. The daily closing values of spot and future prices for select commodities have been collected from both the exchanges. The futures prices are calculated on weighted average of all the futures contracts derived from value and volume of sales data from MCX and NCDEX

IV. MODEL SPECIFICATION

VECM –Garch Model for identifying asymmetry and spillover of volatility.

While conventional time series and econometric models operate under an assumption of constant variance, the ARCH (Autoregressive Conditional Heteroskedastic) process introduced in Engle (1982) allows the conditional variance to change over time as a function of past errors leaving the unconditional variance constant. GARCH (Generalized Autoregressive Conditional Heteroskedasticity), is introduced, allowing for a much more flexible lag structure. The extension of the ARCH process to the GARCH process bears much resemblance to the extension of the standard time series AR process to the general ARMA process (Bollerslev, 1986). To study how volatility responds to good and bad news, EGARCH specification popularized by Nelson (1991) is applied in the present study. Although the GARCH-type models are popular in modeling the volatility process in financial series, the empirical results investigated provide evidence that the EGARCH model can more accurately explain the volatility dynamics (Ramaprasad, 2001; and Clinton and Michael, 2002).To test the causality between spot and futures prices, the following expanded VECM may be estimated using EGARCH representation for each symbol.

$$\Delta s_t = \alpha_{s,0} + \sum_{i=1}^{r} \alpha_{s,i} \Delta s_{t-1} + \sum_{i=1}^{p=1} \beta_{s,i} \Delta F_{t-1} + \delta_s \xi_{t-1} + \varepsilon_{s,t} \text{------------------------------------Eq-1}$$

$$\varepsilon_{s,t} | \Omega_t \sim N(0, \mathrm{h}_{s,t})$$

$$\Delta F_t = \alpha_{f,0} + \sum_{i=1}^{p=1} \alpha_{f,i} \Delta s_{t-1} + \sum_{i=1}^{p=1} \beta_{f,i} \Delta F_{t-1} + \delta_f \xi_{t-1} + \varepsilon_{f,t} \text{-----------------------------------Eq-2}$$

$$\varepsilon_{f,t} | \Omega_t \sim N(0, \mathrm{h}_{f,t})$$

$$\ln(h_{s,t}) = \omega_s + \theta_s \left[\frac{\varepsilon_{s,t-1}}{\sqrt{h_{s,t-1}}}\right] + \gamma_s \left[\left|\frac{\varepsilon_{s,t-1}}{\sqrt{h_{s,t-1}}}\right| - E\left(\left|\frac{\varepsilon_{s,t-1}}{\sqrt{h_{s,t-1}}}\right|\right)\right] + \phi_s \ln(h_{s,t-1}) + \ln(\varepsilon_{f,t}) \text{--------Eq-3}$$

$$\ln(h_{f,t}) = \omega_f + \theta_f \left[\frac{\varepsilon_{f,t-1}}{\sqrt{h_{f,t-1}}}\right] + \gamma_f \left[\left|\frac{\varepsilon_{f,t-1}}{\sqrt{h_{f,t-1}}}\right| - E\left(\left|\frac{\varepsilon_{f,t-1}}{\sqrt{h_{f,t-1}}}\right|\right)\right] + \phi_f \ln(h_{f,t-1}) + \ln(\varepsilon_{s,t}) \text{------Eq-4}$$

In equations (4) and (5), ΔS_t and Δf_t are the first log difference of spot and futures price, $\xi_{s,t-1}$ and $\xi_{f,t-1}$ are the error correction terms obtained from lagged residuals of co-integrating regression of first log difference of spot on futures price and first log difference of futures on spot prices respectively. The error correction terms capture the dynamic linkages between spot price and futures price changes. $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ are the stochastic error terms and α, β and δ are the coefficients to be estimated. 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 mis-specified and the residuals obtained in the first step (and, consequently, the volatility spillovers results) will be biased (Mantu Kumar, 2009).

Ωt-1 is the information set at time, t-1. A condition on the error correction coefficients $|\delta s|+|\delta f| \neq 0$, ensures that lagged disequilibrium ξt-1, occurs in at least one of the equations (Patterson, 2002). The specification of $\varepsilon_{i,t}$ allows for the possibility that they are serially correlated and hence the use of ARCH/GARCH class of models. Moreover, the causality models are very sensitive to the lag length used in the model. The number of lags used in (1) and (2) are determined using the Schwarz Information Criterion (SIC) because of its superiority over other criterions as reported in Reimers (1992).

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Equations (3) and (4) are the conditional variance equations for spot and futures values respectively and reflect the EGARCH (1,1) representations of the variances of $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$. $\ln(h_{s,t})$ and $\ln(h_{f,t})$ are the conditional (time varying) variances of spot and futures values. Conditional on Ω_{t-1}, $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ are assumed to be normally distributed with zero mean and variance of $(h_{s,t})$ and $(h_{f,t})$. The persistence of volatility is measured by ϕ_s for spot values and ϕ_f for futures values. θ_s and θ_f capture the asymmetric behaviour. The lag truncation length (p and q) is determined using Likelihood Ratio (LR) tests and we choose EGARCH (1,1). If $\theta<0$then bad news have leads to more volatilities than good news. If $\theta=1$ there is no existence of asymmetry and both the good and bad news have the same amount of volatility. If $\theta>0$ impact of good news leads to more volatility than bad news.

V. DATA ANALYSIS AND INTERPRETATION

ADF and PSPP tests are used to test the presence of Unit root problem in the prices of selected commodities. Johnsons test has been used to identify the cointegration between the Spot and Futures prices of selected commodities. VECM-GARCH approaches has been considered to identify the presence and direction of the volatility spillovers.

5.1. Unit root test results of the selected commodities.

Unit root test results of the Spot and Futures prices of selected commodities (See Table-1) indicates the presence of unit root problem in the series level but not in their first differences. Both the Augmented Dickey-Fuller test statistic and Phillips-Perron test statistic of the Soya oil, Chana, Silver, Lead and Crude oil shows the presence of unit root problem in the spot and futures prices of selected commodities but not in the returns. All the selected price series are not stationary in the level but are stationary in their first difference.

Table-1: Unit Root Test of the Spot and Futures Prices

Commodity	Augmented Dickey-Fuller test statistic				Phillips-Perron test statistic			
	Series		First Difference		Series		First Difference	
	Test Statistics	Prob	Test Statistics	Prob	Test Statistics	Prob	Test Statistics	Prob
SOY_SP	-1.6161	0.4742	-33.2127	0.0000	-1.6348	0.4646	-49.3851	0.0001
SOY_FP	-1.8918	0.3364	-42.8106	0.0000	-1.9030	0.3312	-43.2873	0.0000
CHA_SP	1.3379	0.9989	-32.8452	0.0000	1.3732	0.9990	-40.5145	0.0000
CHA_FP	1.2410	0.9984	-38.0810	0.0000	1.0941	0.9975	-38.6203	0.0000
SIL_SP	-1.7475	0.4071	-54.1700	0.0001	-1.7635	0.3991	-54.1727	0.0001
SIL_FP	-1.7405	0.4107	-35.6440	0.0000	-1.8349	0.3638	-43.0742	0.0000
LED_SP	-1.9658	0.3023	-53.1422	0.0001	-1.9430	0.3126	-53.1537	0.0001
LED_FP	-1.9156	0.3253	-34.4227	0.0000	-1.8726	0.3456	-39.8223	0.0000
CRI_SP	-1.9048	0.3303	-58.0468	0.0001	-1.9385	0.3147	-58.0787	0.0001
CRU_FP	-1.8150	0.3735	-36.0935	0.0000	-1.7889	0.3864	-41.3771	0.0000

Source: Compiled by author from the analysis results

5.2. Test results of Cointegration between spot and futures prices

The Results of Johansen test of cointegration between spot and future price of select commodities (see table-2) show that cointegration existed between all the spot and future prices. All the select commodities have shown cointegration between their spot and futures prices and there is one cointegration is possible. There is a long term relationship exists between spot and future price of Soya oil, Chana, Silver, Lead and Crude oil.

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Table -2.Johansen Test of Cointegration between Spot and Futures Prices

Variables	Unrestricted Cointegration Rank Test	Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
Soya Oil Spot & Soya Oil Future	Trace	None *	0.014711	40.95415	15.49471	0.0000
		At most 1	0.000943	2.450994	3.841466	0.1174
	Maximum Eigen value	None *	0.014711	38.50316	14.26460	0.0000
		At most 1	0.000943	2.450994	3.841466	0.1174
Chana Spot & Chana Future	Trace	None *	0.017888	39.76657	15.49471	0.0000
		At most 1	0.000567	1.212093	3.841466	0.2709
	Maximum Eigenvalue	None *	0.017888	38.55448	14.26460	0.0000
		At most 1	0.000567	1.212093	3.841466	0.2709
Silver Spot & Silver Future	Trace	None *	0.045932	136.1131	15.49471	0.0001
		At most 1 *	0.000957	2.717137	3.841466	0.0993
	Maximum Eigenvalue	None *	0.045932	133.3960	14.26460	0.0001
		At most 1 *	0.000957	2.717137	3.841466	0.0993
Lead Spot & Lead Future	Trace	None *	0.113229	344.9850	15.49471	0.0001
		At most 1 *	0.001390	3.947734	3.841466	0.0469
	Maximum Eigen value	None *	0.113229	341.0373	14.26460	0.0001
		At most 1 *	0.001390	3.947734	3.841466	0.0469
Cruid Oil Spot & Cruid Oil Future	Trace	None *	0.114719	349.2772	15.49471	0.0001
		At most 1	0.001220	3.464994	3.841466	0.0627
	Maximum Eigen value	None *	0.114719	345.8122	14.26460	0.0001
		At most 1	0.001220	3.464994	3.841466	0.0627

Source: Compiled by author from the analysis results

5.3 Results of VECM and GARCH equations showing causality, volatility spillovers, volatility clustering and asymmetry in the spillovers.

Long run relationships can be obsrved form the Vector Error Correction Model (See table 3). It is observed that unidirectional causality from future to spot is observed in all the selected commodities in the long run.

The coefficient term ‘γ’ indicates the volatility persistence. In all the commodities persistence of volatility is very high indicating that the volatility will remain for a longer period. Volatility persistence is very high Lead spot and futures markets comparatively.

In Silver, Crude oil, Soya Oil and Chana volatility spillovers can be observed from both spot and futures markets as the coefficients ‘φ’ are significant at 5% level of significance. Silver, Crude oil, Soya Oil and Chana bidirectional volatility spillovers are observed and no spillovers are observed in the Lead market. Futures dominance in spillovers is also observed from the coefficients.

There are asymmetries in the volatilities in all the selected commodities spot and futures volatilities as the asymmetry coefficient ‘ω’. Negative news is having more impact on volatilities than that of the positive news in cases Silver spot, Silver futures and Lead futures volatilities. This can be observed from the sign of coefficient ‘θ’. Positive news comparatively having greater impact on volatilities in the Silver spot, Silver futures and Lead futures markets.

Table-3: Results of VECM-GARCH Equation from Spot and Futures prices

	Silver		Lead		Crude oil		Soya Oil		Chana	
	Coeff	Prob	Coeff	Prob	Coeff	Prob	Coeff	Prob	Coeff	Prob
	VECM-Spot Equation									
Coint Eq	-0.2255	0.0000	-0.5186	0.0000	-0.6616	0.0000	-0.0268	0.0000	-0.0350	0.0002
D(LSP(-1)	-0.6893	0.0000	-0.2051	0.0000	-0.3324	0.0000	-0.1938	0.0000	-0.2173	0.0000
D(LSP(-2)	-0.1346	0.0001	-0.0828	0.0082	-0.0821	0.0004	-0.0865	0.0001	-0.0379	0.3097
D(LSP(-3)							-0.0666	0.0027	-0.0498	0.1881
D(LSP(-4)							-0.0083	0.6950	0.0165	0.6522
D(LFP(-1)	0.8904	0.0000	0.4813	0.0000	0.5952	0.0000	0.3510	0.0000	0.5093	0.0000
D(LFP(-2)	0.0953	0.0165	0.0621	0.1111	0.1065	0.0018	0.1481	0.0000	-0.0727	0.0855
D(LFP(-3)							0.1291	0.0000	0.0232	0.5878
D(LFP(-4)							0.0649	0.0042	-0.0496	0.2441
Constant	0.0001	0.5397	0.0001	0.7801	0.0000	0.9960	0.0001	0.4734	0.0005	0.0508
	VECM- Futures Equation									
Coint Eq	0.0084	0.7630	0.0478	0.1621	-0.0228	0.5087	0.0082	0.1815	-0.0008	0.9210
D(LSP(-1)	-0.3845	0.0000	-0.0728	0.0239	-0.1815	0.0000	0.0247	0.2980	-0.0288	0.3912
D(LSP(-2)	-0.0690	0.0404	-0.0374	0.1583	-0.0653	0.0042	0.0165	0.4884	0.0114	0.7390
D(LSP(-3)							0.0294	0.2101	-0.0405	0.2441
D(LSP(-4)							-0.0060	0.7885	0.0325	0.3349
D(LFP(-1)	0.5599	0.0000	0.3534	0.0000	0.3772	0.0000	0.1656	0.0000	0.2265	0.0000
D(LFP(-2)	0.0484	0.2190	-0.0222	0.5007	0.0367	0.2750	-0.0246	0.3052	-0.0581	0.1357
D(LFP(-3)							-0.0018	0.9409	0.0826	0.0359
D(LFP(-4)							0.0248	0.3027	0.0047	0.9055
Constant	0.0002	0.5166	0.0001	0.7661	0.0000	0.9950	0.0002	0.3341	0.0005	0.0498
	EGARCH-VECM Equation- Spot Equation Residuals as Dependent Variable									
π	-0.2746	0.0000	-0.1176	0.0000	-0.1470	0.0000	-0.9983	0.0000	-0.5653	0.0000
ω	0.1746	0.0000	0.1061	0.0000	0.1190	0.0000	0.2151	0.0000	0.1850	0.0000
θ	0.0406	0.0000	-0.0028	0.6235	-0.0123	0.0204	-0.0250	0.0148	-0.0454	0.0007
γ	0.9837	0.0000	0.9956	0.0000	0.9935	0.0000	0.9144	0.0000	0.9516	0.0000
φ	-4.1030	0.0000	-0.4579	0.2709	-2.8188	0.0000	13.8261	0.0000	10.5486	0.0000
	EGARCH-VECM Equation- Spot Equation Residuals as Dependent Variable									
π	-0.3716	0.0000	-0.1412	0.0000	-0.2032	0.0000	-0.4650	0.0000	-0.2865	0.0000
ω	0.2069	0.0000	0.1088	0.0000	0.1402	0.0000	0.1360	0.0000	0.1253	0.0000
θ	0.0398	0.0000	0.0097	0.2324	-0.0207	0.0082	-0.0464	0.0000	-0.0134	0.2861
γ	0.9755	0.0000	0.9935	0.0000	0.9890	0.0000	0.9632	0.0000	0.9789	0.0000
φ	-2.9628	0.0000	-0.5598	0.1781	-1.8359	0.0000	9.4966	0.0000	5.5228	0.0000

Source: Compiled by author from the analysis results

Conditional mean equation

Results indicating dominance of futures in terms of volatility spillover are consistent with the studies of Shihabudheen (2010), Chauhan (2013) and Gupta et al.(2013) but are contradicting the results of Srinivasan(2012) and Manthu Kumar(2014) where spot dominance is observed. It is observed that the information flow is causing volatility first in the futures market and then directed towards spot market.

The negative information impact on volatility is more than the good news in four out of five of the spot prices of selected commodities except Silver where there is no symmetry; which is in contradiction to the study of Ramanarayanan et al.(2011) and Mallilkarjunappa et al.(2010). It is also observed that volatilities in the futures equations of Silver and Lead are indicating more sensitiveness to positive news. The persistence of volatility in case all the spot and futures marketsto be considered by the policy makers and regulators to see that such volatility for a longer time may lead to market collapse. The investors to make right judgments have to watch the negative news or shocks as they cause more volatility in the futures and spot markets and spillover are also present.

VI. CONCLUSION

The cointegration and bidirectional causality is evident from the study. Volatility persistence is evident in all the markets except in soya oil spot market. Presence of spillovers between spot and futures volatilities is also evident except in the Lead. Negative news is more impact on volatilities than positive news in the selected energy and agricultural commodities.

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