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RANDOM WALK AND PRICE CONVERGENCE IN THE COMMODITIES MARKET IN INDIA

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Abstract *This paper investigates whether the commodities market in India follows the random walk process and whether they deviate from the random walk theory (mean reversion). Daily log returns of commodity future index (MCXCOMDEX) and three sectoral indices are examined using the Augmented Dickey-Fuller test (ADF), GARCH, and E-GARCH model to test the random walk theory. This study confirms the existence of random walk for commodity index prices over the period January 2009 to December 2020. ADF test is used for investigating random walk behaviour. From the ADF test we conclude that the series has unit root problem and the index series is non-stationary. The results clearly show that the data is non-stationary possessing a unit root. The GARCH model was used to cater for volatility clustering, which is more pronounced in commodity prices. From the results obtained, it is observed that futures prices are showing volatility clustering and non-stationarity behaviour, which is in line with our research objective of finding the random walk in commodity index; there is a positive result of the existence of random walk.*

Keywords: *Random Walk, Commodity Market, GARCH, ADF, Stationarity, Cointegration, Johansen*

INTRODUCTION

The Indian commodities market has developed drastically since the last two decades. Demand for commodities like metals, oil, coal, and so on have increased tremendously with the increased pace of economic development. The commodities market has opened new options for investment. This increased need of commodities like energy is undoubtedly the result of liberalisation and globalisation of the economy. It led to the formulation of commodity exchanges like MCX (Multi-commodity Exchange) and NCDEX (National Commodity and Derivatives Exchange Ltd.), which are providing a platform for trading commodities in a standardised manner in a large number of commodities. These markets include both the spot and futures trading. These exchanges majorly traded items like precious metals, which consist of gold, silver, and platinum, besides nickel, aluminium, copper, and so on, and commodities like natural gas, crude oil, and so on; in the edible oilseed market, it includes groundnut, mustard seed, sunflower, and many more. The commodities market of India has witnessed a drastic growth, both in the primary as well as in the secondary market. The emergence of national level multi-commodity exchanges and liberalisation in the commodity sector further created enormous opportunities. The market is helpful not only for investment purposes, but also to hedge against inflation, political risk, and in some cases, currency risk.

When the commodities market is used for investment purposes and also for hedging risk, it becomes very important to know how efficient the price is. It becomes necessary to know whether the price in that market reflects the proper information or not. The market is either in the strong form, semi-strong form, or weak form. By weak-form efficient market (random walk hypothesis), we mean that all information contained in historical prices is instantaneously reflected in the current market prices. This effectively precludes the opportunity to detect abnormal returns through a trend trading approach. However, some investment strategies are used to exploit the trend in prices. To study randomness or efficiency in finance and economics, the random walk hypothesis deserves further empirical analysis. Absence of the random walk according to a random walk test indicates the existence of the intertemporal dependence at some chosen lag. A rejection of the random walk hypothesis implies the existence of mean reversion behaviour in asset prices.

Theory of efficient market hypothesis was developed a long time back by Bachelier (1900) and the empirical research of Cowles (1933). If we come to the modern literature, Samuelson (1965) has very clearly and neatly summarised in his article that anticipated prices fluctuate randomly. Fama (1970) summarises that a market in which prices always completely reflect available information is called an efficient market. Recently, for capitals market, Malkiel (1992) gave a

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more explicit definition, which says that a capital market is said to be efficient if it completely and correctly reflects all relevant information in determining prices.

The efficient market hypothesis discussed by Fama (1991) had categorised the efficiency of markets into three sub-categories, namely weak-form, semi-strong-form, and strong-form. This categorisation was done on the basis of availability of information in the market and presence of such information in the stock prices. If all the information and historical price movements are being reflected in the current stock prices, then it is considered as a weak-form of market efficiency. In weak-form of market efficiency, it is not possible to forecast the price changes on the basis of technical analysis. Semi-strong efficiency shows that all the information which is available in the public domain are already reflected in the stock prices; the strong-form of efficiency includes the public as well as private information. Therefore, the semi-strong form eliminates the use of fundamental analysis and the strong-from removes the insider information to make abnormal profits. Evidently, a weaker form of EMH is always a subset of a stronger form.

Kristoufek and Vosvrda (2013) proposed an efficiency index for stock indices, and based on such an index, they ranked various stock indices in their study. They concluded that the stock indices of the European region, the USA, and Japan were found to be the most efficient, whereas the indices of Asia and Latin America were found to be the least efficient. This paper talked about efficiency of stock indices. However, there was no discussion on efficiency of commodity indices.

This paper focuses on commodities futures markets of India using various commodities and analysing the efficiency of the commodities market.

LITERATURE REVIEW

Much research on empirically testing the reaction of security prices to the release of different information has been done. Some of the research on efficiency testing of stock market and price behaviour is done by Beaver (1968), Foster (1981), Ball and Brow (1968), Fama (1970) and Beaver et al. (1979), who find a significant reaction in the security prices to the release of corporate events' announcement information.

The efficiency test and analysis of commodity markets can be done by using the approaches of Fama (1970) because the F test is invalid for market efficiency estimation for non-stationary time series modelling (Elam & Dixon, 1988). Stein (1991) has estimated the social loss due to inefficiency of the futures market. A similar study has been conducted for the futures market in China. The methodology used in the study has been developed from Lai and Lai (1991). The econometric techniques developed by Engle and Granger (1987) and Johnsen and Juselius (1990) for co-integration allow for a Vector Auto Regressive (VAR) model for determination of spot and future prices and allows for testing market efficiency.

Empirical analyses on market efficiency of commodity futures have been conducted mainly for developed countries so far. The examples include Chowdhury (1991) and Kellard (2002) for the UK, and Beck (1994) and McKenzie et al. (2002) for the US. Meanwhile, the relevant studies for emerging countries are significantly growing, but still limited. In this paper, we especially focus on the Indian commodity market; we try to test the presence of random walk in future index prices and we empirically examine whether the market efficient hypothesis holds in the Indian commodity market. More specifically, we estimate the long-run equilibrium relationship between multi-commodity futures and spot prices.

When we talk about the commodity market of India, there have been few studies on the Indian commodity derivatives market. The Indian market study primarily focuses on examining weak-form efficiency. One of the studies on efficiency was done by Sharma and Kennedy (1977). They examined three exchanges, namely BSE, UK, and NYSE, and tried to test the weak-form of efficiency. They found that the results were in support of efficient market hypothesis. Another study using correlation test and run test by Kalawar (1988) on a number of stocks also supported the hypothesis of efficient market; however, it was rejected by Choudhary (1991) in his study conducting similar tests. He rejected the hypothesis that the markets are efficient. Using BSE index data, Poshakwale (1996) showed that the Indian Stock Market was efficient in a weak form. On the same lines, Barman and Madhusoodhan (1991), using unit root test and variance ratio test, Reddy (1998) and Ahmad et al. (2006), using run test and ARCH and GARCH models, all provide evidence in rejection of the hypothesis of efficient markets.

Among those studies, the most prominent is that of Pravakar (2009), who examined the efficiency and future trading price nexus of five top selected commodities (gold, copper, petroleum crude, soya oil, and chana). Research suggested that the market is efficient for all five commodities. Other studies have tried to analyse the efficiency of commodity markets in the developed countries. There is another study on market efficiency and bias in agricultural commodities (live cattle, hogs, and soybean) (Andrew & Mathew, 2002).

Normally, it is said that the futures market has two important functions: one is price risk management and the second is price discovery. By taking equal but opposite positions in the futures market, both the producer and the consumer can manage the price risk in the spot market, which is usually called the hedging of price risk in commodities. Apart from these participants who aim to hedge, there must also be someone in the futures market who aim to take risk and profit by doing so (Easwaran & Ramasundaram, 2008). Having market participants with various objectives and information, the futures market enables the current futures price to act as an accurate indicator of the spot price expected at the maturity of the futures contract. This is referred to as the price discovery function of the futures market. Only an efficient futures market can perform these functions. As proposed by Fama (1970), we consider the market as weak-form efficient if the futures price reflects all available information for predicting the future spot price and no participant can make a profit consistently.

Lee and Lee (2009) studied major commodities such as coal, natural gas, crude oil, and power, with panel tests for stationarity, and concluded that the commodities indices in the sample were inefficient.

Wang and Yong (2010) studied energy commodities futures markets using non-linear models and found that these indices were inefficient, especially when the markets were bullish. Gebre-Mariam (2011) studied the natural gas index of the USA using spot and futures prices. This study focuses on the US natural gas market (spot and futures) finding no arbitrage opportunities for daily prices; however, in general, the author claims that the markets can be seen as efficient only for contracts with approximately a month to maturity.

Wang and Yang (2010) studied high-frequency futures data of crude oil, heating oil, gasoline, and natural gas using various non-linear models. For heating oil and natural gas, the authors found market inefficiencies which are profound, mainly during the bull market conditions.

Zunino et al. (2011) used permutation entropy and permutation statistical complexity to check the efficiency of commodity markets and found that copper, cotton, and silver were found to be the most efficient commodities. Wang et al. (2011) studied the futures prices of gold with multi-factorial detrended fluctuation analysis and concluded that the markets became more efficient over years. Kim et al. (2011a) studied the Korean agricultural indices with detrended fluctuation analysis and found that the agricultural commodities having anti-correlation and strong volatility clustering resulted in inefficiency of markets. In another study, Kim et al. (2011b) used random matrix theory and network analysis to check the efficiency of stock indices and commodity indices and found them to be dissociated. Forecasting earnings help manage risk and guide investors to choose quality stock for better returns (Aghazadeh et al., 2014).

The literature suggests that the efficiency analysis of commodity indices with respect to a diverse portfolio of commodities can give productive results.

The reason why so much research has focused on the question of market efficiency is because of the important implications conveyed by efficient market hypothesis. If markets are efficient, then prices fully reflect all the information present in the market and, hence, there is no scope for making profits using either technical analysis or fundamental analysis of financial markets. If we assume that financial markets are efficient, then an expert will not do any better than a layman in predicting price movements. This idea was more strongly put forward by Malkiel (2003), who indicated that in an efficient market an investor cannot earn returns greater than those that could be obtained by holding a randomly selected portfolio of individual stocks (with a comparable level of risk).

There are many empirical studies which have looked at the issue of market efficiency for different stock markets and the recent literature on the efficient market hypothesis has given increasing attention to emerging markets. Some studies of the efficient market hypothesis in emerging stock markets are those of Chaudhuri and Wu (2003, 2004), Gough and Malik (2005), Cooray and Wickremasinghe (2008), Lean and Smyth (2007), Phengpis (2006), Joshi et al. (2021b), and Joshi et al. (2022). Lim and Brooks (2011) provide a comprehensive review of the relevant literature.

This study extends the existing literature on testing the efficient market hypothesis in emerging stock markets in two ways. First, we contribute to the burgeoning literature pertaining to the efficiency of the Indian stock market. Several recent studies have used unit root tests to examine the efficient market hypothesis in the Indian stock market (see e.g. Ahmed et al., 2006; Ali et al., 2013; Alimov et al., 2004; Gupta & Basu, 2007; Jayakumar et al., 2012; Jayakumar & Sulthan, 2013; Kumar & Maheswaran, 2013; Kumar & Singh, 2013; Mahajan & Luthra, 2013; Mehla & Goyal, 2012; Srivastava, 2010, and Joshi et al., 2021a). However, these studies typically employ the Dickey-Fuller and/or Phillips-Perron unit root tests without structural breaks (see e.g. Ahmed et al., 2006; Ali et al., 2013; Alimov et al. 2004; Gupta & Basu, 2007; Jayakumar et al., 2012; Jayakumar & Sulthan, 2013; Kumar & Singh, 2013; Mahajan & Luthra, 2013; Mehla & Goyal, 2012; and Srivastava, 2010). Moreover, some of the studies use short spans of data (see e.g. Ali et al., 2013 and Jayakumar & Sam, 2012). The failure to account for structural breaks and the use of short spans of data impair the reliability of existing findings. We advance the literature on the efficiency of the Indian stock market by employing unit root tests, which allow for up to two breaks, have better size and power, and, in the case of the Narayan and Liu (2013) test, address the presence of heteroscedasticity.

The second way in which we extend the literature is to contribute to studies of the efficient market hypothesis in stock markets in emerging markets more generally. Existing studies related to efficiency of emerging markets have reached mixed results; for example, Chaudhuri and Wu (2003) found that the random-walk hypothesis was rejected for ten out of the 14 emerging markets considered. Phengpis (2006), using the same dataset as Chaudhuri and Wu (2003), showed that their results weaken when a different methodology for testing the random-walk hypothesis is adopted. Chaudhuri and Wu (2003) followed the Zivot and Andrews (1992) method for determining a structural break, whereas Phengpis (2006) used the Lee and Strazicich (2003a) approach. Narayan and Smyth (2005) used data on stock prices for 22 OECD countries, and employed the Zivot and Andrews (1992) sequential trend break test and the Im, Pesaran et al. (2003) panel unit root test. They found that OECD prices follow a random walk, in spite of the presence of significant structural breaks in the data. Narayan and Smyth (2007) examined G7 stock price data using the Lumsdaine and Papell (1997) and Lee and Strazicich (2003a; 2003b) tests and found that the random-walk hypothesis is supported for all the G7 countries, except for Japan. A general consensus is that stock prices in developed markets are found to exhibit a random walk, whereas there are no definite conclusions regarding stock prices in emerging markets (Nurunnabi, 2012).

Review of literature indicates that much empirical research has been done for studying efficiency of stock markets in developed and developing countries, including India. However, not much research has been done on testing the efficiency of the commodity markets internationally, and particularly in the Indian context, for individual commodities or for a group of a few commodities. Hence, this paper attempts at testing the presence of random walk in the Indian commodities market, with reference to commodity futures index on MCX.

DATA SOURCES

The data used in this study is daily future index prices from January 2009 to December 2020. Four commodity indexes are studied, namely MCXCOMDEX (Commodity Index), MCXAGRI (Agricultural Commodity Index), MCXENERGY (Energy Commodity Index), and MCXMETAL (Metal Commodity Index). These indices are abbreviated as C, A, E, and M, respectively. The data series is also transformed into daily log returns series by taking the first difference of the logarithm of the prices to give the log returns.

Although, Mahadevan (2021) studied that hedging can be done without financial instruments as well. Studying volatility may help reduce the risks involved in trading, and therefore, it is considered an important variable in the futures market to measure the time period for the market to include new information, as price fluctuation within a duration is displayed (Desai & Joshi, 2021).

Rizvi et al. (2022) studied the impact of precedented and unprecedented events on the Indian stock returns using event study methodology and found that the markets are volatile in the short term in terms of price and returns. They studied the volatility effects of the events and the market efficiency of the Indian stock market. Joshi et al. (2022) studied the relationship between open interest and volatility in commodity markets using the E-GARCH model and found that volatility persists in the futures prices. In addition, the Granger causality tests are consistent with previous studies, that is, open interest causes futures prices for commodity futures. Open interest relies on futures price movements that have taken all information regarding speculators and hedges. It was found that any trader or investor can utilise such information and evidence of open interest to forecast futures prices for commodities futures.

The closing prices of selected indices were collected from the official websites of commodity exchanges. In case the data was not available for a particular index, the data was collected from Bloomberg.

METHODOLOGY

Random walk model for the commodity index price P_t can be written as follows:

$$P_t = \beta_0 + P_{t-1} + \varepsilon_t \tag{1}$$

We define the natural logarithmic returns (simply log returns) for commodity index, agricultural index, energy index, and metal index at time t as:

$$R_t = \text{In } P_t - \text{In } P_{t-1} \tag{2}$$

Where, $P_t = P_{t-1} + \varepsilon_t$ is the price of index at time t.

The simplest model which can be used to test for random walk is the simple autoregressive (AR (1)) model, namely:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \varepsilon_t \tag{3}$$

Where, $R_t = P_t - P_{t-1}$ is the log return of price; and β_0 and β_1 are the parameters that need to be estimated and is the natural logarithm of the price at time t. Values of parameters determine the efficiency of the price.

If a time series is stationary and its mean and variance remain the same at various lag lengths, such a series is called a time invariant series. Such a series has mean reversion behaviour and revolves around the mean and broadly constant amplitude. A non-stationary time series has a time varying mean and variance; thus, it follows a random walk pattern (Gujarati, 2012).

According to Greene (2003), the efficacy of model using time series variables depends on the stationarity of variables. To check the unit root, the standard Dickey-Fuller model has been 'augmented' by $\boldsymbol{Y_{t-1}}$. In this case, the regression model and the t-test are referred to as the ADF test.

$$\Delta Y_t = \mu + \beta Y_{t-1} - \sum_{j=1}^{p} \alpha j \, \Delta Y_{t-1} + \varepsilon_t \tag{4}$$

The ADF unit root test has a H_0: $\beta = 0$ versus an H_1: $\beta < 0$. Thus, if the series has a unit root, it implies that co-integration is necessary.

The predictability of time series data can be analysed by comparing variances of returns calculated over various time intervals. For this purpose, the overlapping variance ratio test (Lo & MacKinlay, 1988, 1989) is adopted. If the underlying assumption is that the series follows a random walk, the variance of a q-period difference should be q times the variance of the one-period difference. Evaluating the empirical evidence for or against this restriction is the basis of the variance ratio test.

In this paper, variance ratio test for homoscedastic and heteroscedastic random walks, using the asymptotic normal distribution (Lo & MacKinlay, 1988), was used.

GARCH (1,1) Model

Commodity index prices exhibit large volatility, leading to time varying variances, violating the assumption of a constant variance (homoscedasticity). The GARCH model can be used to verify the volatility clustering in such a time series data. In the GARCH model, systematic variance change over time is allowed to detect its departure from the random walk. The GARCH (p,q) model has a p lagged squared error term and q lagged conditional variance term. This is known as the GARCH (1,1) model, which has proved useful in modelling returns of financial assets. The GARCH (1,1) test is based on the following equations:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \beta_2 \sigma^2_{t-1} + \varepsilon_t \tag{5}$$

$$\sigma^2_t = y_0 + y_1 \varepsilon^2_{t-1} + \alpha_1 \sigma^2_{t-1} \tag{6}$$

The GARCH (1,1) model checks for changes in the random walk and allows the error term to deviate from the assumption of normally distributed, independent, and homoscedasticity. In the above model, σ_t is conditional variance of error term ε_t of the GARCH (1,1) model. Parameters y_0, y_1, and α_1 represent changing volatility. The model measures three important things: first is change in slope and intercept of the model represented by β_0 and β_1, second is the time-varying variance of the error term, and third is the level of risk by measuring conditional variance of log returns.

The Exponential GARCH Model (E-GARCH)

The E-GARCH model can be generalised to describe more lags in the conditional variance. The non-negativity constraints on the parameters are not there in the E-GARCH model. The ARCH term will be categorised into two independent variables, which indicate the sign effect of shocks on index volatility and the size (magnitude) effect of shocks on the volatility.

$$LOG\ (GARCH) = C(2) + C(3)*ABS\left(\frac{RESID(-1)}{SQRT(GARCH(-1))}\right) + C(4)* + C(5)*\ LOG\ (GARCH(-1))\left(\frac{RESID(-1)}{SQRT(GARCH(-1))}\right) \tag{7}$$

ANALYSIS AND RESULTS

Table 1: Descriptive Statistics of Prices

	C	A	E	M
Mean	3030.878	2212.675	2922.042	3856.407
Median	3006.180	2185.550	2717.690	4214.720
Maximum	4689.600	3716.580	5137.100	5741.310
Minimum	1654.590	1372.040	1471.680	1987.960
Std. Dev.	652.1314	481.6926	748.3034	986.7658
Skewness	0.005380	0.474975	0.555713	−0.264594
Kurtosis	1.846709	3.041526	2.478435	1.556894
Jarque-Bera	179.8537	122.2458	203.7991	319.4427
Probability	0.000000	0.000000	0.000000	0.000000
Sum	9835199.	7180132.	9482027.	12514041
Sum Sq. Dev.	1.38E+09	7.53E+08	1.82E+09	3.16E+09
Observations	3245	3245	3245	3245

Source: Authors' calculation.

Table 2: Descriptive Statistics of Returns

	RTC	RTA	RTE	RTM
Mean	0.0000661	0.0000869	−0.0000632	0.000135
Median	0.000377	3.12E−05	0.000415	0.000575
Maximum	0.054383	0.100981	0.076225	0.055493
Minimum	−0.061197	−0.214791	−0.078006	−0.10516
Std. Dev.	0.00955	0.009758	0.01642	0.010647
Skewness	−0.338263	−4.966558	0.004903	−0.92086
Kurtosis	6.652555	120.9158	5.235844	10.97639
Jarque-Bera	1865.718	1893297	675.9194	9060.959

	RTC	RTA	RTE	RTM
Probability	0.0000	0.0000	0.0000	0.0000
Sum	0.214418	0.281909	−0.205056	0.438843
Sum Sq. Dev.	0.295852	0.30887	0.874624	0.367767

Source: Authors' calculation.

The descriptive statistics depicted in Table 1 show that mean prices of MCXMETAL in the sample is highest (3856.407) among all the indices, followed by MCXCOMDEX index; average daily prices of MCXAGRI is the lowest. The standard deviation of daily prices indicated that MCXMETAL is more volatile compared to other indices.

The descriptive statistics depicted in Table 2 show that mean returns of all of the indices in the sample were positive, except MCXENERGY index. It was found that the mean daily return of MCXAGRI was highest (0.00000869) among all the indices, followed by the MCXCOMDEX index.

Skewness values exhibit an asymmetrical distribution with a long tail to the right. All the kurtosis values of the stock markets investigated in this study display a value more than three, showing a leptokurtic curve, which demonstrates that the distribution of stock returns in these countries contains extreme values. The values of kurtosis, accompanied by those of Jarque-Bera statistic, clearly indicate that the returns of these markets are not normally distributed.

Fig. 1 and Fig. 2 are the graphical representation of daily price and log return of commodity indexes, respectively. The graph clearly shows that the daily prices are not stationary, while the graph of the returns shows the existence of volatility and volatility clustering.

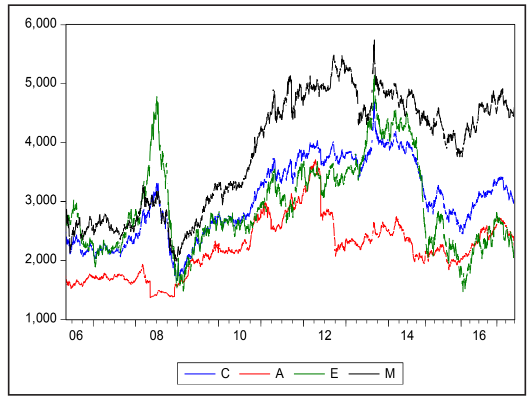

Fig. 1: Future Index Price

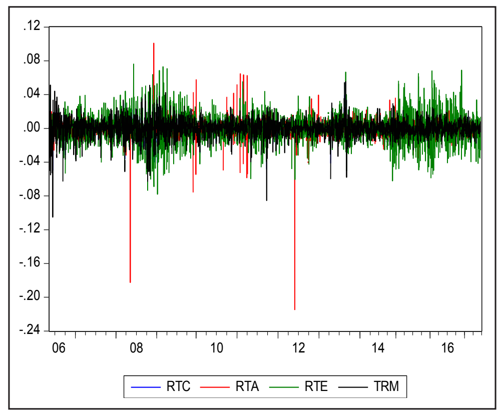

Fig. 2: Future Index Returns

Table 3: Unit Root Test Estimate for Log Index Price

Index	Variable	Order of Integration	T-Statistic	P-Value	Stationarity
COMDEX	Close	I(0)	−1.373237	0.5969	Non-stationary
	Lnr close	I(0)	−116.0323	0.0001***	Stationary
AGRI	Close	I(0)	−1.558158	0.5040	Non-stationary
	Lnr close	I(0)	−116.7048	0.0001***	Stationary
ENERGY	Close	I(0)	−1.604110	0.4803	Non-stationary
	Lnr close	I(0)	−80.46711	0.0001***	Stationary
METAL	Close	I(0)	−1.182250	0.6843	Non-stationary
	Lnr close	I(0)	−107.3066	0.0001***	Stationary

Source: Authors' calculation.

The ADF test was performed for each of the index in the sample included to check the stationarity of the data. The ADF test estimates in Table 3 show the test for stationarity for log price of all the four commodity indices. Null hypothesis of unit root (non-stationary) cannot be rejected at level. Thus, the log prices follow the I(1) order of integration. Thus, at 5% and 1% significance level, the null hypothesis is not rejected, implying that log index price is non-stationary. Non-stationarity implies random walk (Geman, 2007). As can be seen from Table 3, the p-value is less than 1% for all the variables at 1st difference level. It was found that all the commodity indices prices are non-stationary at the original level and they are stationary at the 1st difference.

Table 4: Variance Ratio Test

Index	Variable	T-Statistic	P-Value
COMDEX	Close	1.896871	0.2121
	Lnr close	18.48113	0.0000***
AGRI	Close	3.643638	0.0011
	Lnr close	14.74972	0.0000***
ENERGY	Close	2.416951	0.0612
	Lnr close	24.05802	0.0000***
METAL	Close	1.480633	0.4497
	Lnr close	10.97004	0.0000***

Source: Authors' calculation.

The results of the variance ratio test in Table 4 indicate that log prices of all four commodity indices in the sample follow a random walk. Thus, at 1% significance level, the null hypothesis is rejected, implying that log index price is a random walk (Geman, 2007).

Table 5: Conditional Volatility Results

Index	Intercept	GARCH (−1)	RESID (−1)^2
MCXCOMDEX	1.24E−06 (0.0000)	0.926102 (0.0000)	0.059667 (0.0000)
MCXAGRI	4.04E−05 (0.0000)	0.502079 (0.0000)	0.092646 (0.0000)
MCXENERGY	1.90E−06 (0.0000)	0.941929 (0.0000)	0.051574 (0.0000)
MCXMETAL	1.54E−06 (0.0000)	0.926911 (0.0000)	0.058229 (0.0000)

Source: Authors' calculation.

From the GARCH (1,1) estimates in Table 5, the coefficients of lagged square error term and lagged conditional variance term are highly significant at 1%. As lagged conditional variance affects current conditional variance, it can be inferred that the returns of all four commodity index exhibit volatility clustering. It is clear evidence that log returns of commodity indices possess time-varying and time-correlated volatility, thus violating the assumption of homoscedasticity.

E-GARCH (1,1) Model

The E-GARCH model indicated the effect of volatility clustering on imminent conditional volatility in the returns of the indices (Table 6). Hence, NH-3 (There is no volatility clustering on imminent conditional volatility) was rejected. The results indicated that the conditional volatility of the sample indices had volatility clustering.

Table 6: Results of E-GARCH Model for Volatility Clustering

Index	Variable	Z-Statistic	P-Value	H0: NO GARCH (No Volatility Clustering)
COMDEX	Close	2029.010	0.0000	Rejected, Volatility Clustering
	C2	−3.409	0.0007	
	C3	10.573	0.0000	
	C4	0.328	0.7426	
	C5	38.021	0.0000	
	Lnr close	7086.682	0.0000	
	C2	−14.93	0.0000	
	C3	18.388	0.0000	
	C4	−1.929	0.0537	
	C5	302.0535	0.0000	
AGRI	Close	3710.724	0.0000	Rejected, Volatility Clustering
	C2	−5.869	0.0000	
	C3	9.516	0.0000	
	C4	0.125	0.9004	
	C5	48.844	0.0000	
	Lnr close	1364.704	0.0000	
	C2	−135.275	0.0000	
	C3	0.161	0.8722	
	C4	−5.505	0.0000	
	C5	1.397	0.1621	
ENERGY	Close	2040.989	0.0000	Rejected, Volatility Clustering
	C2	−3.529	0.0004	
	C3	11.611	0.0000	
	C4	0.402	0.6876	
	C5	47.335	0.0000	
	Lnr close	4342.978	0.0000	
	C2	−11.461	0.0000	
	C3	12.947	0.0000	
	C4	−4.094	0.0000	
	C5	224.620	0.0000	
METAL	Close	3071.918	0.0000	Rejected, Volatility Clustering
	C2	−3.939	0.0001	
	C3	13.915	0.0000	
	C4	−0.614	0.5394	
	C5	46.469	0.0000	
	Lnr close	6429.442	0.0000	
	C2	−18.457	0.0000	

Index	Variable	Z-Statistic	P-Value	H0: NO GARCH (No Volatility Clustering)
	C3	18.786	0.0000	
	C4	−0.112	0.9112	
	C5	457.471	0.0000	

Source: Authors' calculation.

Volatility clustering was found to exist in each of the indices in the sample at different levels. As the p value of F statistics and observed R squared was less than 1%, it indicated the existence of volatility clustering in the stock markets. The main explanation for different levels of volatility clustering may be because of the development of these indices and mysterious behavioural aspects of stockholders.

CONCLUSION

In this study, an attempt has been made to determine whether commodity index futures prices are mean reverting or are a random walk process. For this purpose, two approaches, namely the Augmented Dickey-Fuller (ADF) test and the GARCH model, are used. Data which was used was the daily index values of the commodity futures from 2009 to 2020. From the ADF test, we conclude that the commodity futures indices have unit root problem and the series is non-stationary. Thus, the ADF test, used to test for stationarity in the data set from 2009 to 2020, shows clearly that the data is non-stationary, possessing a unit root. This implies non-stationarity, leading to the preliminarily conclusion that these indices do behave in a random-walk-like fashion. These conclusions are in line with Geman's (2007) paper. Stationarity implies no random walk and non-stationarity implies random walk (Geman, 2007).

The GARCH model was used to cater to volatility clustering, which is more pronounced in commodity and stock prices. It was found that commodity index futures are more predictable, which means they do follow a random walk. From results obtained, it is observed that futures prices are showing volatility clustering and non-stationarity behaviour. These are in line with our research objective of finding the random walk in commodity index; positive results of existence of random walk is observed.

The available literature has generally analysed the cointegrating relation between the spot and futures prices of the individual agricultural commodities, and has used the sample period before the phenomenal growth in traded value of commodity futures in India. In fact, the total value of commodities traded has shown a significant growth since 2009-20. Moreover, in line with this trend, the commodity price indices have also increased since the middle of 2010. The result of our paper implies that, as the market size expands, the commodity futures and spot prices are random walk cointegrates in the long run. This means the market fulfils a weak form of efficiency in that the futures price generally operates as an unbiased predictor of the future spot price.

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