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Price Discovery and Volatility Spillover in Commodity Futures and Spot Market in India: An Empirical Analysis

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Abstract

Purpose: This paper aims to investigate the price discovery process, persistence of volatility and spillover of volatility in commodity futures and spot market in India.

Methodology: In this paper, commodities namely, mentha oil, cotton, gold and aluminium have been selected to explore the process of price discovery, volatility persistence and spillover of volatility using cointegration test, vector error correction (VECM), granger causality and GARCH model.

Findings: The results of VECM suggest that price discovery takes place in futures market in case of all commodities except for mentha oil where price discovery occurs in spot market. The Block Exogeneity Wald test (granger causality) results also show that futures market has stronger ability to predict the spot prices. The results of GARCH model indicate that volatility is persistent for all commodities except mentha oil futures return. In the support of VECM and granger causality test results, GARCH model results also indicate that volatility spillovers from futures return to spot return for all selected commodities except cotton where volatility spillovers from spot return to futures return.

Practical Implications: The findings of this study significantly contribute to the Indian commodity derivatives market literature and useful for future researchers, investors, hedgers, economists and policy makers.

Originality: There are very few studies that have examined the price discovery process and spillover of volatility using combination of both agricultural and non-agricultural commodities in India.

Key words: *Aluminium, Commodity market, Cotton, Mentha oil, Price Discovery*

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1. Introduction

It is believed that futures market dominate the price discovery process as futures market is more innovative and efficient in discounting new information. Thus, this market helps in discovering prices for the underlying spot market. Despite of this, there is an argument that futures prices rise price volatilities of the underlying commodity market. India has a long history of commodity futures trading as it was commenced in India in 1875. The first commodity was cotton which attract the futures trading in India and leads to the establishment of Bombay cotton trade association Ltd in 1893. Futures trading in oilseeds and bullions started in 1900 and 1920. In 1952, Forward Contracts (Regulation) Act, 1952, was enacted. Commodity futures market was relatively popular till early 1970s but its growth was frought due to ban put by government on futures trading in all commodities except two commodities turmeric and pepper (Forward Market Commission, 2012-13). On the recommendations of Khusro Committee which was established in 1980, Commodity futures market re-organised in 2003 in which the prohibition on futures trading of most of the commodities was lifted and three national electronic commodity exchanges namely "National commodity and derivative exchange (NCDEX)"; "Multi commodity exchange (MCX)" and "National multi commodity exchange (NMCE)" were recognized. A major change came in the history of commodity market in 2015 when FMC merge into SEBI and SEBI became the new regulator of commodity market.

This paper aims to investigate the price discovery process, persistence of volatility and spillover of volatility across agricultural (mentha oil and cotton) and non-agricultural (gold and aluminium) commodities traded on MCX. Price discovery is one of the functions of commodity futures market (Garbade & Silber, 1983). "Price discovery refers to the use of futures prices for pricing spot market transactions"(Garbade & Silber, 1983). The concept of volatility relates to the uncertainty about an asset's price. Volatility of prices has become a major issue for researchers in financial economics and analysts in financial markets. Volatility spillover is described as how volatility in one market affects the volatility in another market (Ranganath et al., 2017).

Mentha is an arometic herb which is also known as Japanese Pudina in India. Major Mentha oil markets are in Uttar Pardesh. Mentha oil and its derivatives are used in pharmaceutical, food, flavorings and perfumery industry. The largest producer and exporter of mentha oil and its derivatives is India (Vimal, 2014).

Cotton is mainly grown for fiber which is used to make textile all over the world. World's largest Cotton producing countries are India, China, U.S. and Pakistan (Samal, 2017). Hence, Cotton is important for India's global trade (www.mcx.com).

Gold is the oldest precious metal and it has been valued as a commodity, global currency, an investment and an object of beauty. Gold is affected by world macroeconomic

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factors such as movement in dollar, economic events and interest rate. In India, Gold is also effected by marriage, seasonality and harvesting.

Aluminium is the most widely used non-ferrous metal. Aluminium is the third most abundant element existing in the earth's crust. It is a unique metal which has the characteristics of light weight, flexible, durable, strong and impermeable. Aluminium is rust resistant and 100 per cent recyclable. All the characteristics of aluminium make it a highly attractive metal. It is mainly used in defense, transportation, consumer electronic industries and packaging (cans). Aluminium is more used in developed countries in compare to developing countries.

This study may be useful to future researchers, investors, hedgers, economists and policy makers. It extends price discovery and volatility spillover literature for commodity derivatives market.

The rest of the study is arranged into four sections. Section 2 reviewed the available literature on price discovery process and volatility spillover. Details about the methodology are provided in the section 3. Section 4 explains the results and discussions and section 5 concludes the results, policy implications and the future research of direction.

2. Briefing of Reviewed Literature

There have been many studies in developed as well as developing countries like India which studied the price discovery mechanism. Numerous studies have been conducted taking various commodities traded on different exchanges in different countries. In India also, a vast literature on price discovery is available. A brief picture of the reviewed literature is given below:

Pavabutr and Chaihetphon in 2010 explored the price discovery process of gold futures contracts and shows that prices of futures market lead to prices of spot market. Kumar and Arora (2011) also examined the role of gold futures market in price discovery process in Indian commodity market by analyzing the data from 2005 to 2009. Using johansen's cointegration test and granger causality test, the study found that price discovery happening in the futures market of gold. Similar results were found by Nirmala and Deepthy (2016). Dangi in 2014 again revealed that futures market leads the spot market of silver based on the period from January 2008 to December 2012 by employing cointegration test and causality test, thereby supporting Nirmala and Deepthy (2016). As opposed to this, Sridhar et al. (2016) found completely different results. Their findings revealed that spot market can be used as a tool for discovering the prices of futures market in case of silver. Iyer and Pillai in 2010 investigated the price discovery and convergence of information from one market to another for six shortlisted commodities by applying a two–regime threshold autoregrssion and a two-regime threshold vector auto regression (TVAR) and evidenced that price discovery takes place in five commodities except nickel and the convergence of information rate is slow. Arora and Kumar in 2013 analyzed the role that futures market played in price discovery mechanism of copper and aluminium market by applying augmented dickey fuller test to test the stationarity, Johansen cointegration test for long run relationship and vector error correction model to test causality. Using the data from 2006-2011, the authors concluded that futures market is more efficient in discounting the new information than the spot market. Sehgal et al. (2012) studied the price discovery relationship of 10 agricultural commodities for the period from 2003 to 2012. The study found that price discovery is confirmed for all commodities except turmeric. Peri et al. (2013) investigated the price discovery in corn and soybean commodities taking data from 2004 to 2010 by using VAR, ADF-GLS test and ZA test. The result of the examination showed that prices of futures market play a vital role in discovering the spot price but there are some cases such as in crises and in strong price increase phases, then prices of spot market play a major role in price discovery. Shakeel and Purankar (2014) also studied the price discovery in top three agricultural commodities traded on NCDEX i.e., soybean, castor seed and chana considering period from 2009 to 2014 using cointegration test and vector error correction model and inferred that both markets (spot and future) plays leading role in price discovery. Ali and Gupta (2011) analyzed the efficiency of futures market taking a sample of 12 agricultural commodities traded at NCDEX and suggested that futures prices has enough ability to predict the spot prices. Inani (2018) also confirmed that futures prices of agricultural commodities are more efficient in price discovery. Agrawal et al. (2020) examined the information efficiency in Indian agricultural commodity derivatives market and results indicated that spot market leads price discovery in case of cotton while in mentha, the price discovery leads by futures market. Jore (2018) studied the volatility in gold, silver and copper metals in India covering the period from January 2014 to December 2016 by applying GARCH (1, 1) model. Authors concluded that copper and silver metal returns were highly volatile than gold returns. Authors also inferred that copper is more volatile in compared to silver. The empirical research on combination of both methodologies price discovery process and volatility spillover is found to be sparse in context to India. Shihabudheen and Padhi in 2010 studied the volatility spillover and price discovery process and concluded that volatility spillover from futures to spot market are dominant for all selected commodities except sugar where volatility spillover exists from spot to futures market. Similar results were obtained in Revi (2013) and Mahalik et al. (2014). Srinivasan (2012) investigated the price discovery and volatility spillover considering four spot-futures indices of MCX and findings revealed that bidirectional volatility exist between spot and futures indices. Ranganath et al. (2017) also found the presence of bidirectional volatility. Srinivasan and Ibrahim in 2012 examined the gold market and showed that there exists volatility spillover from spot market to futures market. Barreto and Ramesh (2018) examined the volatility spillover in non-agricultural commodities by applying EGARCH (1, 1) model and confirmed the existence of volatility spillover effect for most of the commodities.

Joarder and Mukherje (2021) examined the lead lag relationship between the spot and futures prices considering oil and oilseed contracts traded on NCDEX by applying granger causality test, augmented dickey fuller test, cross correlation and regression analysis and showed that information related to futures market volatility helps to assess the spot market volatility.

Due to continuously change in market conditions and macroeconomic variables like government policies, fluctuations in international market etc., the role of price discovery function has been regularly researched on different commodities by applying different econometric tool taking data of various time periods to gain more clarity in this regard. Most of the studies conducted in this area in the context of India have been on volatility spillover and price discovery. There is hardly any attempt to examine the price discovery, persistence of volatility and spillover of volatility across agricultural (mentha oil and cotton) and non-agricultural (gold and aluminium) commodities traded on MCX. The above discussion will give rise to the following questions:

a. Does the futures market play a lead role in price discovery of sampled commodities?

b. Is there a persistence of volatility in spot and futures market of sampled commodities?

c. Whether the volatility spillover from futures market to spot market.

3. Methodology

Price discovery process follows a two step procedure. In first step, long run relationship is tested between variables and in second step, causality is examined between variables (Quan, 1992). For testing long run relationship between futures and spot market, cointegration test has been applied. We have used the johansen's cointegration test in the present study. Vector error correction model (VECM) has been applied to examine the price discovery process between spot and futures market. There is prerequisite of cointegration analysis and causality test that a unit root test is to be employed to test whether the given price series are stationary or not.

3.1 Unit Root Test

As we know, there is prerequisite of cointegration analysis and causality test that a unit root test is to be performed to test the stationarity of price series. This paper uses

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the Augmented Dickey Fuller test (Dickey & Fuller, 1981) and Phillips-Perron test to examine the stationarity of spot and futures prices and their return series. These tests are standard test. The Augmented Dickey Fuller test equation is presented as:

$$\Delta X_t = \beta_1 + \beta_2 t + \delta X_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta X_{t-i} + \varepsilon_t (1)$$

Where,

X= price series, β_1 = a constant, ΔX_t = first difference of X_t , ε_t = error term

The Phillip Perron test equation is specified as

$$\Delta X_t = \delta X_{t-1} + \beta_i D_{t-I} + \varepsilon_t \quad (2)$$

Where,

D_{t-i} = deterministic trend component

3.2 Cointegration Test

Since both price series are stationary at first difference, then there is a possibility of cointegration relationship among the series. A cointegrating relationship is inferred as long term equilibrium relationship and it allows more than one cointegrating relationship. Given that the price series are integrated of the same degree of integration, hence, Johansen's cointegration test has been applied (Johansen 1988, 1991). Under the johansen's cointegration approach, two test statistical approaches, namely, trace test and maxi-eigen test are conducted. These tests are constructed as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} ln(1-\lambda_i) \quad (3)$$

And

$$\lambda_{max}(r, r+1) = -T \, ln(1-\lambda_{r+1}) \quad (4)$$

Where,

T is the sample size and is estimated value for ith ordered eigen value obtained from the matrix. test the null hypothesis that "number of cointegrating vectors is less than or equal to r" against the alternative hypothesis that "number of cointegrating vectors is more than r". tests the null hypothesis of "number of cointegrating vectors is r" against the alternative hypothesis that "the number of cointegrating vector is r+1". In this test, the trace statistics and max-eigen statistic values are compared with their critical values.

3.3 Vector Error Correction Model

After having cointegration among the variables, VECM proposed by Johansen (1988) is applied to estimate the price discovery process between the variables. Equation (5) and (6) are formulated to estimate the error correction term for the spot and futures prices. The optimal lag length of model is estimated using AIC information criteria.

$$\Delta S_t = \alpha_S + \sum_{i=1}^{m} \beta_{Si} \Delta S_{t-i} + \sum_{j=1}^{m} \gamma_{Fj} \Delta F_{t-j} + \lambda_S Z_{t-1} + \varepsilon_{St} \quad (5)$$

$$\Delta F_t = \alpha_F + \sum_{i=1}^{m} \beta_{Fi} \Delta F_{t-i} + \sum_{j=1}^{m} \gamma_{Sj} \Delta S_{t-j} + \lambda_F Z_{t-1} + \varepsilon_{Ft} \quad (6)$$

$$Z_{t-1} = S_{t-1} - \delta F_{t-1} \quad (7)$$

Where,

S_t and F_t are logarithmic daily spot prices and futures prices, Δ is the first difference operator, α_S and α_F are constants and Z_{t-1} is the ect.

In the above equations, Z_{t-1}(first part) refers to the equilibrium error. This captures how the spot (futures) prices adjust to the previous period's change that arises from the long run equilibrium. The remaining part represents the short run effect of previous period's change in price on current period's deviation. λ_F and λ_S are the speed of adjustment coefficient. The magnitude of these coefficients λ_F and λ_S reveal the direction of causality and determine the speed at which deviation from equilibrium is corrected.

Granger causality test proposed by granger (1969) is used to determine whether futures (spot) prices can be better predicted with the past values of both futures and spot prices than only futures (spot) prices. The model of granger causality is as follows:

$$\Delta S_t = \sum_{i=1}^{m} a_{1i} \Delta S_{t-i} + \sum_{j=1}^{m} b_{1j} \Delta F_{t-j} + \varepsilon_{1t} \quad (8)$$

$$\Delta F_t = \sum_{i=1}^{m} a_{2i} \Delta F_{t-i} + \sum_{j=1}^{m} b_{2j} \Delta S_{t-j} + \varepsilon_{2t} \quad (9)$$

3.4 GARCH Model

The GARCH model developed by Bollerslev in 1986 is used to examine the persistence of volatility and impact of volatility in one market (futures or spot) on the future volatility in other market (spot or futures). GARCH model is an extension to ARCH (Autoregressive Conditional Hetroscedasticity) econometric model. GARCH model

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allows the conditional variance to be dependent upon its own past and on the past error terms. So, the specification of GARCH (1, 1) model is:

$$\sigma_t^2 = \omega + \alpha_1 u_{t-1}^2 + \beta\, \sigma_{t-1}^2 (10)$$

is called as conditional variance as it is one period ahead forecast variance based on any past information. In equation 2, one more exogenous variable is included, the square of the lagged error terms of other variable, estimated with the help of ARMA forecasting models. The new equation can be constructed as follows:

$$\sigma_t^2 = \omega + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2\, \varepsilon_{t-1}^2 \ (11)$$

In the above equation, the last term $\beta_2$represents the square of the lagged error terms of other variable. The significant value of this coefficient indicates the volatility spillover effect from one variable to another variable. Diagnostic test namely Ljung – Box (Q^2) Statistics and ARCH LM test has been used to check the model adequacy. Ljung – Box (Q^2) Statistics test the null hypothesis of "no autocorrelation in the residuals" against the alternative hypothesis of "autocorrelation in the residuals". The null hypothesis of ARCH LM test is that "there is no ARCH effect in the residuals". The alternative hypothesis of ARCH LM test is that "there is ARCH effect in the residuals".

4. Results and Discussion

4.1 Data Description

Four commodities namely mentha oil, cotton, gold and aluminium have been selected for analyzing the price discovery process, persistence of volatility and spillover of volatility in commodity derivatives market. These commodities are selected from four different categories i.e, oil and oil seeds, agriculture commodities, bullions and base metals. The choice of these commodities based on their production in India. India is a significant producer and exporter of these commodities. Data set consist of the daily closing prices of spot market and near month futures contracts of sampled commodities which has been compiled from MCX's official website ranging from Jan 2009 to March 2020 (mentha oil, gold and aluminium). Cotton data is available from September 2011 and hence ranging from September 2011 to March 2020.

4.2 Basic Statistics of Price Series

Figure1 to 4 graphically exhibit the futures and spot prices of mentha oil, cotton, gold and aluminium. It can be found in following figures that both price series are moving together for all commodities. Hence, they seem to be cointegrated. Table 1 highlights the descriptive statistics of mentha oil, cotton, gold and aluminium. The return series of mentha oil, cotton, gold and aluminium are positively skewed (except the futures return series of mentha oil and spot return series of cotton) indicating that these series

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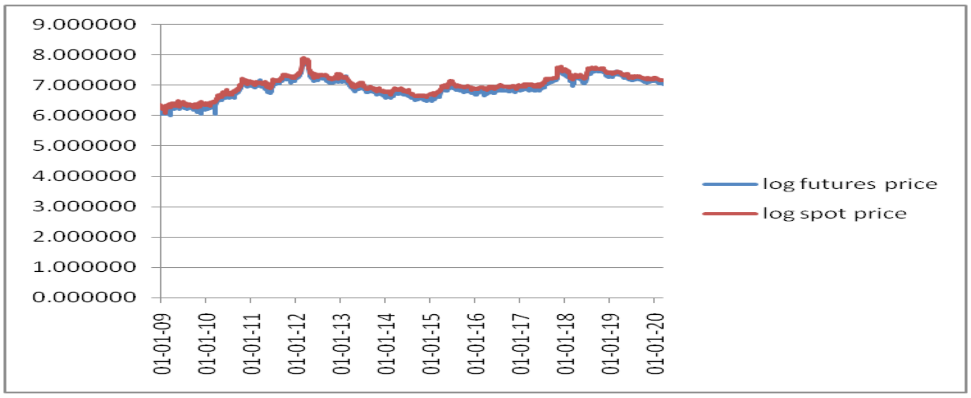
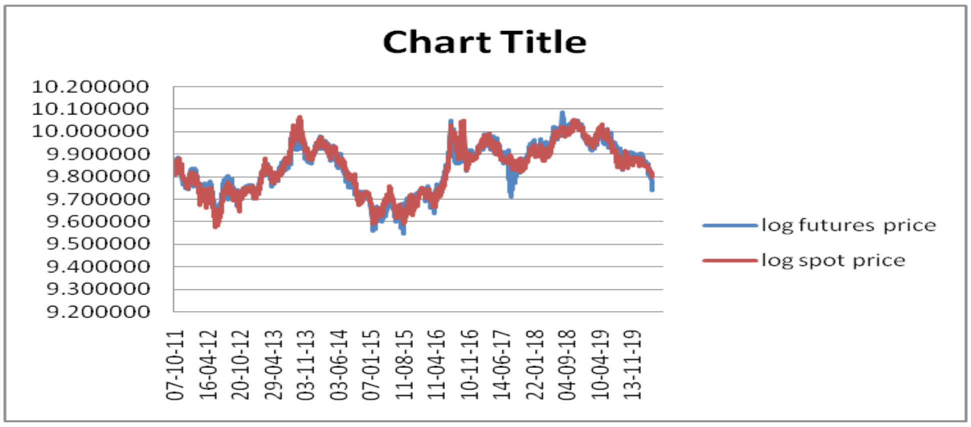
have higher probability of positive returns. The value of kurtosis of all the return series of selected commodities reveal that the data is leptokurtic () which shows the higher variability of returns. The null hypothesis for Jarque- Bera is that the series is that the series is normally distributed. This null hypothesis is rejected for mentha oil, cotton, gold and aluminium because the value of probability for selected commodities is significant at 1%.

Figure1: Graphical Presentation of Mentha oil Price Series



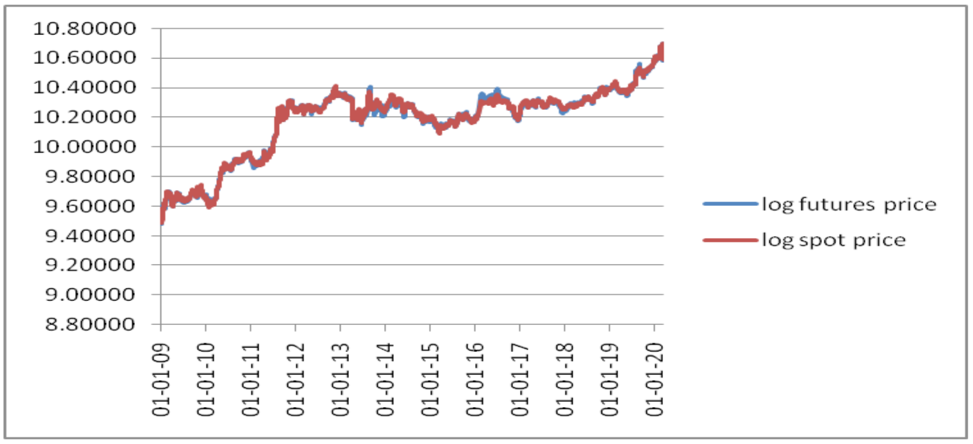
Source: Author's calculations.

Figure 2: Graphical Presentation of Cotton Price Series



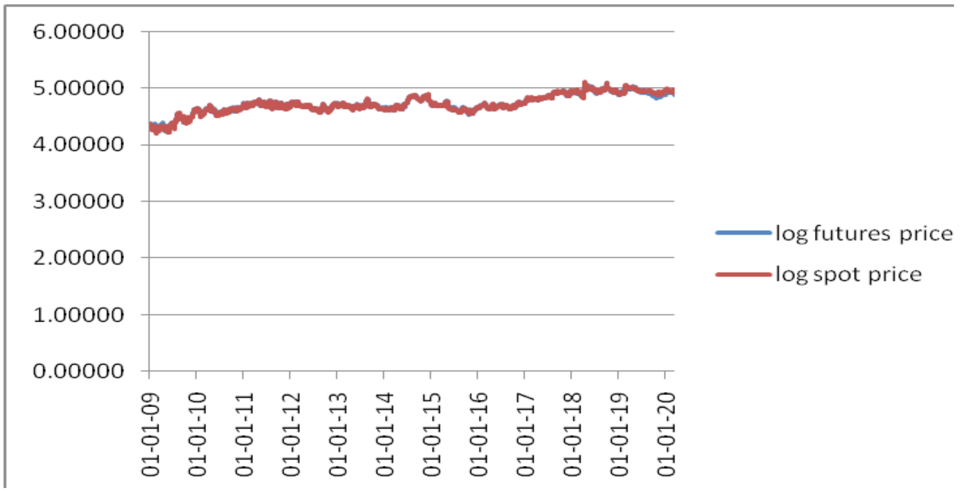
Source: Author's calculations.

Figure 3: Graphical Presentation of Gold Price Series



Source: Author's calculations

Figure 4: Graphical Presentation of Aluminium Price Series



Source: Author's calculations

Please refer to table-1 at the end of the paper

4.3 Unit Root Test

This paper uses the unit root test based on Augmented Dickey Fuller test (ADF) and Phillips-Perron (PP) test to examine the stationarity of futures and spot price series. Table 2 presents the results of unit root test. It can be seen from the table 2, the price series of futures and spot prices are found to be non- stationary at level. Hence, these series are transformed by taking first difference to make them stationary. The results show that futures and spot return series for mentha oil, cotton, gold and aluminium are significant at 1% level of significance. Thus, futures and spot price series became stationary after first differencing.

Please refer to table-2 at the end of the paper

4.4 Johansen's Cointegration Test

This test is used on futures and spot prices of four commodities applying two approaches: (i) trace test and (ii) max-eigen test. This test is sensitive to the lag selection. The VAR model has been employed to determine the optimal lag length. On the basis AIC criteria, five lags are selected for mentha oil and aluminium. Three lags are selected for cotton. Eight lags are selected for gold. The table 3 displays the results of cointegration test. The values of trace and max-eigen statistics for mentha oil, cotton, gold and aluminium are significant at 1% level. Hence, the null hypothesis of no cointegration (r=0) is rejected and suggested that cointegration relationship exists among spot and futures prices. However, null hypothesis of one cointegration vector (r=1) cannot be rejected for mentha oil, cotton, aluminium and gold. There exist one cointegrating vector in case of mentha oil, cotton, aluminium and gold. Thus, results shows that spot and near month futures price series are cointegrated and there exist long run relationship for all sampled commodities.

Please refer to table-3 at the end of the paper

4.5 Vector Error Correction Model

After having cointegration among the variables, VECM (vector error correction model) proposed by Johansen (1988) is used to estimate the price discovery process in futures and spot markets of selected commodities. On the basis of lag exclusion wald test, five lags are found to be appropriate for mentha oil and Aluminium, three lags are found to be appropriate for cotton, while eight lags are found to be appropriate for gold. Table 4 presents the results of vector error correction model.

The error correction term also known as speed of adjustment is significant at 1% and 5% level of significance in case of all commodities except mentha oil spot equation and cotton futures equation. This indicates that when the cointegrated series are in disequilibrium in the short run, both the series, i.e. spot prices as well as futures prices adjust in order to re-establish the equilibrium for gold and aluminium.

In case of gold, cotton and aluminium, coefficient of error correction term in spot equation (0.037, 0.036 and 0.104) is greater than the futures equation (0.035, 0.016 and 0.049) in absolute terms. Higher coefficient shows higher adjustment towards equilibrium. Thus, spot market makes a greater adjustment to re-establish the equilibrium. It indicates that futures market leading the spot market and price discovery takes places in futures market of gold, cotton and aluminium. The coefficient of error correction term in futures equation is greater than the spot equation for mentha oil. In this case futures market makes a greater adjustment to re-establish the equilibrium.

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The opposite interpretation could be drawn for mentha oil where spot market leading the futures market. This indicates that price discovery takes place in the spot market for mentha oil.

Please refer to table-4 at the end of the paper

To investigate the short run lead-lag relationship among spot and futures prices, Block Exogeneity Wald test (granger causality) has been conducted. Table 5 shows the results of Block Exogeneity Wald test (granger causality) and indicate that there exist bidirectional causality between spot price and futures price of sampled commodities, which is consistent with interpretation of ECT results except mentha oil and cotton where unidirectional causality is identified by ECT results. Thus, prices in both markets have the capability to predict the prices of other markets. However, futures market leads spot market for three commodities out of four with high value of chi-square statistic. The futures market of commodities serves as a benchmark for deciding the prices of all commodities except mentha oil. The results of Block Exogeneity Wald test supports the results of vector error correction model which proves the lead role of futures market in price discovery of sampled commodities.

Please refer to table-5 at the end of the paper

4.6 GARCH Model

The persistence of volatility in futures and spot market and direction of volatility spillover between spot and futures market for mentha oil, cotton, gold and aluminium has been examined by applying GARCH model. Before applying GARCH model, it is necessary to analyze the heteroscedastic nature of the series.

The heteroscedasticity tests such as ARCH LM test is employed to prove the heteroscedasticity or ARCH effect in the time series. The Ljung – Box (Q^2) Statistics tests the presence of serial correlation in the residuals up to 36 lags. The results of ARCH LM test and Ljung – Box (Q^2) Statistics for the selected commodities are presented in the table below:

Please refer to table-6 at the end of the paper

The results reports in table 6 shown that the problem of heteroscedasticity is present in both the return series of all selected commodities as the test statistics are significant at 1% level. So, the null hypothesis of ARCH LM test is rejected against the alternative hypothesis of ARCH LM test. Similarly, the existence of serial correlation in the residuals up to 36 lags is also observed.

The presence of ARCH effect and serial correlation confirm that the use of ARCH/ GARCH family models is the appropriate model for measuring the volatility. Thus, GARCH model could be applied. GARCH (1,1) model is found to be best fit for all commodities except for futures prices of mentha oil where GARCH(1,2) is found to be fitted on data. Table 7 reports the GARCH model results**.** The results of GARCH shows that the coefficients of GARCH term are positive and significant except mentha oil futures equation which suggest that volatility persistent in all sampled commodities except mentha oil futures return. Table 8 reports the results of volatility spillover. The coefficient of β_2 represents the volatility spillover from spot returns to futures return and vice-versa. The results of volatility spillover show that volatility spillover exists from futures return to spot return in case of all selected commodities except cotton where volatility spillovers from spot return to futures return. This means that the volatility in futures return influences the volatility in the future movement of the spot return. The study claims that volatility spillovers from future to spot because the value of squared lagged residual in future return is larger than the spot return but the reverse exists in the case of cotton. Diagnostic tests have been performed to check the model adequacy by employing the testing for autocorrelation (Q^2-statistics) and ARCH test respectively. The diagnostic test results indicate that there is no serial correlation at 36 lags and ARCH effects in the residuals as the coefficients are found to be statistically insignificant.

Please refer to table-7 at the end of the paper

Please refer to table-8 at the end of the paper

5. Concluding the Results, Policy Implications and Future Direction of Research

This paper aims to investigate the price discovery process, persistence of volatility and spillover of volatility in commodity futures and spot market in India by first analyzing the lead role of futures market in price discovery, and seconds the persistence of volatility in futures and spot market and third is the direction of volatility from futures to spot or vice-versa. On the basis of the objective of the study, three research questions were formulated. The answers of the research questions were determined by applying Johansen's cointegration test, vector error correction model (VECM), granger causality test and GARCH model. The results of cointegration test confirm the presence of long term relationship between markets. The empirical findings of VECM and granger causality test reveal that futures market plays a dominant role in price discovery and effectively serves the price discovery in spot market in case of cotton, gold and aluminium while mentha oil exhibit good price discovery in futures market. The results of GARCH model indicate that volatility is persistent in all sampled commodities except mentha oil futures return. The results of volatility spillover reveal that spillover of volatility exists from future to spot as evidenced by the value of squared lagged residual in future return which is larger than the value of squared lagged residual in spot return whereas the reverse exists in cotton. Our results are consistent with the results of Mahalik et al. (2014).

5.1 Policy Implications

The findings of the study significantly contribute to the Indian commodity derivatives market literature and useful for future researchers, investors, hedgers, economists and policy makers to decide their arbitrage strategies and investment policies.

5.2 Future Direction of Research

Price discovery process in this study has been studied by establishing the relationship between spot and futures market. But there are many other determinants that impact the price discovery process. No attention has been paid to those determinants. This study has taken four commodities only traded on MCX. Future research can be conducted by considering more agricultural and non-agricultural commodities traded on MCX and NCDEX.

References

Agrawal, T. J., Sehgal, S., & Kumar, M. (2020). Market development and policy issues for agri-derivatives in India: A study of cotton and mentha. *Agricultural Economics Research Review*, *33*(1), 99-108.

Ali, J., & Gupta, B. K. (2011). Efficiency in agricultural commodity futures markets in India: Evidence from cointegration and causality tests. *Agricultural Finance Review*, *71*(2), 162-178.

Arora, S., & Kumar, N. (2013). Role of futures market in price discovery. *Decision, 40* (3), 165-179.

Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, 31, 307-327.

Bretto, B. E., & Ramesh, B. (2018). Price discovery and volatility spillover in metal commodity market in India. *Indian Journal of Accounting, 50*(1), 97-106.

Dangi, V. (2014). Role of commodity market in price discovery mechanism in India: A study of silver. *Business Perspectives and Research*, *2*(2), 15-24.

Dickey, D.A., & Fuller, W.A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: Journal of the Econometric Society*, *49*(4), 1057–1072.

Forward Market Commission. (2013). Annual Report 2012-13. Retrieved from https://www.sebi.gov.in/sebiweb/other/OtherAction.do?doFmc=yes&type=1

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Management Review
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Garbade, D. K., & Silber, L. W. (1983). Price movements and price discovery in futures and cash markets. *The Review of Economics and Statistics*, 289-297.

Granger, C. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 423–438.

Inani, K. S. (2018). Price discovery and efficiency of Indian agricultural commodity futures market: An empirical investigation. *Journal of Quantitative Economics, 16*(1), 129-154.

Iyer, V., & Pillai, A. (2010). Price discovery and convergence in the Indian commodities market. *India Growth and Development Review, 3*(1), 53-61.

Joarder, S., & Mukherjee, D. (2021). The Lead–Lag Relationship Between Futures and Spot Price—A Case of the Oil and Oilseed Contracts Traded on Indian Exchange. *Arthaniti: Journal of Economic Theory and Practice*, *20*(1), 7-33.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12* (2–3), 231–254.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica*, *59* (6), 1551–1580.

Jore, S., & Shrivastava, V. (2018). A study of volatility of select metals traded in the Indian commodity market. *NMIMS Management Review, XXXV* (4), 50-72.

Kumar, N., & Arora, S. (2011). Price discovery in precious metals market: A study of gold. *The Indian Journal of Commerce, 64*(4), 38-46.

Mahalik, M. K., Acharya, D. & Babu, M. S. (2014). Price discovery and volatility spillovers in futures and spot commodity markets: Some Indian evidence. *Journal of Advances in Management Research*, *11*(2), 211-226.

Nirmala, S., & Deepthy, K. (2016). Price discovery in commodity markets: A study of precious metals market in multi commodity exchange. *International Journal of Multidisciplinary Research and Modern Education, 2*(2), 571-577.

Pavabutr, P., & Chaihetphon, P. (2010). Price discovery in the Indian gold futures market. *Journal of Economics and Finance, 34*(4), 455-467.

Peri, M., Baldi, L., & Vandone, D. (2013). Price discovery in commodity markets. *Applied Economics Letters, 20*(4), 397-403.

Quan, J. (1992). Two-step testing procedure for price discovery role of futures prices. *The Journal of Futures Markets (1986-1998)*, *43*(1), 139-149.

Ranganath, G., Venkatram, R., & Mahendran, K. (2017).Volatility spillover effects between futures and spot markets - Case of agricultural commodity derivatives in India. *International Journal of Agricultural Science and Research, 7*(4), 625-634.

Ravi, S. (2013). Price discovery and volatility spillover in Indian commodity futures markets using selected commodities. *Indian Journal of Research, 2*(12), 128-130.

Samal, P. G. (2017). Price discovery efficiency of cotton futures market in India. *Agricultural Economics Research Review*, *30*(2), 235-244.

]Sehgal, S.,Rajput, N., & Dua, K. R. (2012). Price discovery in Indian agricultural commodity markets. *International Journal of Accounting and Financial Reporting, 2*(2), 34-54.

Shakeel, M., & Purankar, S. (2014). Price discovery mechanism of spot and futures market in India: A case of selected agri commodities. *International Research Journal of Business and Management, 8*(8), 50-61.

Shihabudheen, M. T., & Padhi, P. (2010). Price discovery and volatility spillover effect in Indian commodity market. *Indian Journal of Agricultural Economics,* 65(1), 101-117.

Sridhar, L. S., Sumathy, M., Sudha, N., & Charles Ambrose, A. (2016). Price discovery in commodity market–An empirical study on the silver market. *IOSR Journal of Economics and Finance (IOSR-JEF)*, *7*(2), 88-95.

Srinivasan, P. (2012). Price discovery and volatility spillovers in Indian spot-futures commodity market. *IUP Journal of behavioral finance*, *9*(1), 70-85.

Srinivasan, P., & Ibrahim, P. (2012). Price discovery and asymmetric volatility spillovers in Indian spot-futures gold markets. *International Journal of Economic Sciences and Applied Research*, *5*(3), 65-80.

Vimal, S. (2014). Profitability of mentha oil futures for farmers. *International Journal of Management, MIT College of Management*, *2*, 44-48.

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Table1. Descriptive Statistics

Commodities	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis	J-B	Probability
Mentha oil									
Spot price	1160.55	1092.4	2769.3	501.5	393.065	0.564	3.497	166.813	0.000
Futures price	1046.69	978.5	2475.9	464.9	356.335	0.703	3.778	283.590	0.000
Spot return	0.000	0.000	0.146	-0.145	0.017	0.210	15.052	15959.940	0.000
Futures return	0.000	0.000	0.193	-0.204	0.027	-0.030	13.471	12033.48	0.000
Cotton									
Spot price	18882.83	18950	23720	14420	2255.674	0.044	1.973	97.604	0.000
Futures price	18848.74	19020	24180	13990	2166.503	0.019	2.006	90.860	0.000
Spot return	0.000	0.000	0.043	-0.044	0.007	-0.160	9.235	3583.24	0.000
Futures return	0.000	0.000	0.078	-0.104	0.012	0.024	10.865	5686.603	0.000
Gold									
Spot price	26822.56	28428.5	44315	12935	6063.206	-0.423	2.962	89.736	0.000
Futures price	26868.81	28380	44458	12787	6089.221	-0.416	2.949	86.964	0.000
Spot return	0.000	0.000	0.068	-0.072	0.008	0.075	10.571	7182.57	0.000
Futures return	0.000	0.000	0.122	-0.086	0.009	0.598	18.975	32141.37	0.000
Aluminium									
Spot price	113.214	110.100	171.050	62.550	18.172	0.118	3.323	21.807	0.000
Futures price	113.514	110.850	168.750	63.750	17.630	0.082	3.433	29.177	0.000
Spot return	0.000	0.000	0.123	-0.117	0.013	0.438	12.521	12448.280	0.000
Futures return	0.000	0.000	0.103	-0.094	0.012	0.558	8.8970	4904.066	0.000

Source: Author’s Calculations.

Notes: SD indicates standard deviation and J-B indicates Jarque-Bera.

Table 2: Results of ADF and PP Test

Commodities	ADF	Phillips- Perron(PP)
Mentha oil		
FP	-2.374(0.149)	-2.613(0.090)
SP	-2.306(0.170)	-2.373(0.1497)
FR	-59.834*(0.000)	-59.488*(0.000)
SR	-21.716*(0.000)	-48.491*(0.000)
Cotton		
FP	-2.339(0.160)	-2.236(0.194)
SP	-1.825(0.368)	-2.252(0.188)
FR	-50.150*(0.000)	-50.150*(0.000)
SR	-38.484*(0.000)	-41.893*(0.000)
Gold		
FP	-1.106(0.716)	-1.143(0.701)
SP	-0.849(0.804)	-0.928(0.780)
FR	-54.592*(0.000)	-54.602*(0.000)
SR	-53.696*(0.000)	-53.796*(0.000)
Aluminium		
FP	-2.745(0.067)	-2.524(0.110)
SP	-2.682(0.077)	-2.423(0.135)
FR	-59.724*(0.000)	-60.451*(0.000)
SR	-39.250*(0.000)	-64.040*(0.000)

Source: Author's Calculations. Notes: Significant at: *0.01 levels; values in brackets shows Mackinnon (1996) -values.SP and SR stand for spot price and spot return; and FP and FR stand for futures price and futures return.

Table3. Results of Johansen Cointegration Test

Commodities	Trace statistics		Max-eigen statistics	
	λ_{trace}	*p -value*	λ_{max}	*p -value*
Mentha oil				
H0:r=0	88.794*	0.000	83.040*	0.000
H0:r≤1	5.755*	0.016	5.755**	0.016
Ctton				
H0:r=0	63.150*	0.000	58.408*	0.000
H0:r≤1	4.742**	0.029	4.742**	0.029
Gold				
H0:r=0	55.526*	0.000	54.650*	0.000
H0:r≤1	0.876	0.349	0.876	0.349
Aluminium				
H0:r=0	116.557*	0.000	110.113*	0.000
H0:r≤1	6.444**	0.011	6.444**	0.011

Notes: Significant at: *0.01 levels; significant at: **0.05 levels.

Table4. Vector Error Correction Model Results

Commo-Dities	Mentha oil		Cotton		Gold		Aluminium	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.010 [-0.710]	-0.123* [-7.014]	0.036* [-6.494]	-0.016 [-1.630]	-0.037* [3.559]	-0.035** [-2.445]	-0.104* [-6.134]	0.049* [2.621]
ΔS_{t-1}	0.150* [6.651]	-0.258* [-9.098]	0.167* [11.966]	-0.064* [-2.611]	0.571* [30.758]	-0.011 [-0.424]	-0.440* [-17.825]	0.062* [2.292]
ΔS_{t-2}	0.041*** [1.722]	-0.169* [-5.688]	0.043* [2.943]	-0.039 [-1.543]	0.268* [11.822]	-0.038 [-1.203]	-0.210* [-8.092]	0.090* [3.140]
ΔS_{t-3}	0.088* [3.733]	-0.040 [-1.364]	0.003 [0.208]	-0.003 [-0.105]	0.107* [4.552]	-0.027 [-0.836]	-0.219* [-8.650]	-0.006 [-0.199]
ΔS_{t-4}	0.118* [5.215]	0.013 [0.448]			0.035 [1.485]	-0.06** [-2.011]	-0.13*** [-5.519]	0.019 [0.749]

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ΔS_{t-5}	0.107* [5.244]	0.037 [1.428]			0.014 [0.595]	-0.08** [-2.459]	-0.052* [-2.815]	-0.033 [-1.639]
ΔS_{t-6}					-0.050** [-2.153]	-0.08** [-2.576]		
ΔS_{t-7}					-0.079* [-3.465]	-0.117* [-3.76]		
ΔS_{t-8}					-0.077* [-3.838]	-0.09* [-3.08]		
ΔF_{t-1}	-0.005 [-0.171]	0.338* [9.960]	0.043*** [1.849]	0.07*** [1.681]	-0.433* [-18.09]	0.08** [2.490]	0.568* [23.431]	-0.050** [-1.885]
ΔF_{t-2}	-0.057** [-2.070]	0.224* [6.492]	0.038 [1.643]	0.059 [1.455]	-0.224* [-8.522]	0.058 [1.605]	0.357* [13.319]	-0.028 [-0.950]
ΔF_{t-3}	-0.009 [-0.336]	0.111* [3.191]	0.037*** [1.736]	0.035 [0.921]	-0.074* [-2.767]	0.100* [2.705]	0.217* [8.051]	-0.047 [-1.577]

ΔF_{t-4}	-0.05*** [-1.907]	0.024 [0.689]			-0.035 [-1.295]	0.040 [1.082]	0.138* [5.365]	-0.015 [-0.513]
ΔF_{t-5}	-0.144* [-5.766]	-0.046 [-1.468]			0.030 [1.118]	0.121* [3.290]	0.900* [3.999]	-0.005 [-0.191]
F_{t-6}					0.086* [3.220]	0.097* [2.669]		
F_{t-7}					0.091* [3.634]	0.115* [3.340]		
F_{t-8}					0.037*** [1.932]	0.058** [2.199]		
Constant t-statistics	0.224 [0.454]	0.165 [0.266]	-0.126 [-0.047]	-0.770 [-0.163]	6.975** [2.037]	7.524 [1.593]	0.016 [0.711]	0.018 [0.735]

Notes: lag length is determined by Akaike's Information Criteria (AIC). (***), (**), (*) indicates probabilities values are significant at 10%, 5 % and 1% level of significance. S denotes spot prices and denotes futures prices. Values in parentheses are t-values. Source: Author's Compilation.

Table5. Results of Block Exogeneity Wald Test

Excluded	Chi-square	d. f.	Probability
Mentha oil			
D. variable: Spot price			
Future price	77.242	5	0.000*
D. variable: Futures price			
Spot price	120.908	5	0.000*
Cotton			
D. variable: Spot price			
Future price	144.736	3	0.000*
D. variable: Future price			
Spot price	6.335	3	0.096***
Gold			
D. variable: Spot price			
Future price	1042.999	8	0.000*
D. variable: Future price			
Spot price	27.947	8	0.001**
Aluminium			
D. variable: Spot price			
Future price	553.174	5	0.000*
D. variable: Future price			
Spot price	23.977	5	0.000*

Notes: (***), (**) and (*) indicates the level of significant at 10 %, 5 % and 10 % respectively.

Source: Author's Calculations.

Table 6. Heteroscedasticity and Autocorrelation Test

Commodities	ARCH LM Test Obs*R-squared	Prob. Chi-Square	Squared Residuals (Q^2 statistics)
Mentha oil FR	122.7776	0.0000	Q^2(36)=376.54(0.0000)
Mentha oil SR	125.3275	0.0000	Q^2(36)=150.48(0.0000)
Cotton FR	20.23291	0.0000	Q^2(36)= 59.038(0.0090)
Cotton SR	18.7762	0.0000	Q^2(36)=255.37(0.0000)
Gold FR	7.6355	0.0057	Q^2(36)=110.03(0.0000)
Gold SR	145.0736	0.0000	Q^2(36)=743.63(0.0000)
Aluminium FR	36.1576	0.0000	Q^2(36)= 191.31(0.0000)
Aluminium SR	137.371	0.0000	Q^2(36)=271.93(0.0000)

Source: Author's estimation. Notes: SR denotes spot return and FR denotes futures return.

Table 7. Analysis of GARCH Model

Futures Return	Mentha oil	Cotton	Gold	Aluminium
Mean Equation				
Constant	0.0013*	0.0002	0.0002	0.0002
AR(1)	-0.0780*			
MA(3)	0.0359**			
AR(7)		-0.9138*		
MA(7)		0.9335*		
AR(1)			0.9823*	
MA(2)			-0.9831*	
AR(1)				-0.0446*
MA(2)				0.0306
Variance Equation				
C	0.0005*	0.0001*	0.0000*	0.0000*
ARCH effect	0.3055*	0.2919*	0.0903*	0.1500*
GARCH effect	-0.0261	0.3216*	0.7230*	0.6000*
Spot Return				
Mean Equation				
Constant	-0.0003	0.0000	0.0003***	0.0002***
AR(2)	-0.8784*			
MA(2)	0.8497*			
AR(1)		0.8874*		
MA(1)		-0.7659*		
AR(1)			-0.8261*	
MA(2)			0.8496*	
AR(1)				-0.6026*
MA(2)				0.5306*
Variance Equation				
C	0.0000*	0.0000*	0.0000*	0.0000*
ARCH effect	0.1740*	0.1500*	0.0613*	0.1500*
GARCH effect	0.8304*	0.6000*	0.8985*	0.6000*

Source: Author's calculations. Notes: (***), (**), (*) indicates probabilities values are significant at 10%, 5% and 1% level of significance.

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Table 8. Volatility spillover results

Dependent Variable	Constant	ARCH(-1)	ARCH(-2)	GARCH(-1)	Squared residuals after ARMA model: Futures return	Squared residuals after ARMA model: Spot return	Residual Diagnostic: Q^2- Stat	Residual Diagnostic: ARCH Test
Mentha oil								
Futures return	0.0001*	0.236*	-0.2145*	0.8600*		0.064*	9.806(0.877)	0.746(0.388)
Spot return	0.0000*	1.90E-01*		8.20E-01*	3.70E-03*		9.601(1.000)	0.738(0.390)
Cotton								
Futures return	0.0001*	0.2952*		0.3155*		-0.019	35.767(0.480)	0.310(0.578)
Spot return	0.0000*	7.80E-02*		8.80E-01*	8.10E-03*		19.528(0.988)	1.160(0.282)
Gold								
Futures return	0.0000*	0.066*		0.8752*		0.046*	14.308(1.000)	0.001(0.975)
Spot return	0.0000*	6.40E-02*		3.90E-01*	3.40E-01*		30.637(0.721)	1.154(0.283)
Aluminium								
Futures return	0.0000*	0.0550*		0.7513*		0.035*	32.622(0.630)	1.148(0.284)
Spot return	0.0001*	6.40E-02*		3.60E-01*	2.10E-01*		43.387(0.130)	0.627(0.428)

Source: Author's estimates. Notes:*indicates significance at 1%. P-value is given in parenthesis.