CHAPTER 5

ANALYSIS AND INTERPRETATION

5.1 TO ANALYSE THE MARKET BEHAVIOUR OF COMMODITIES FUTURE AND SPOT PRICES

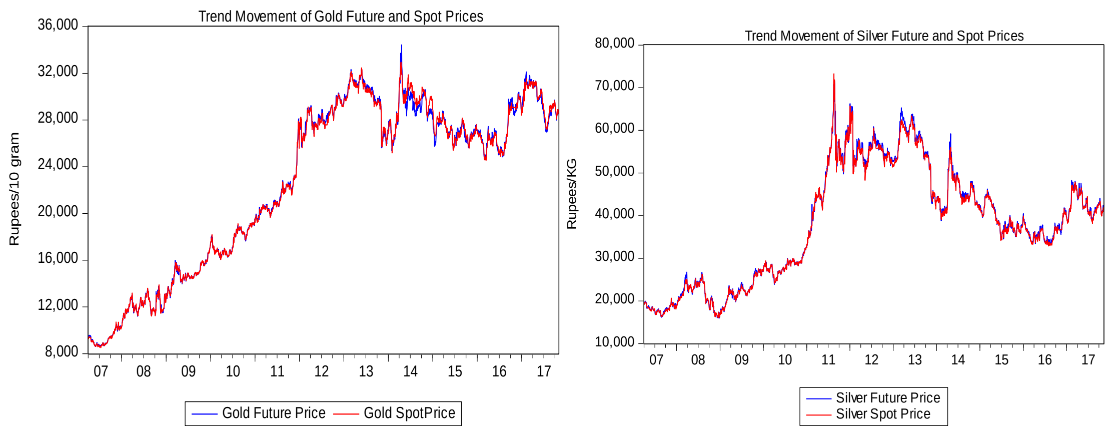
Commodity market is a very dynamic market which offers opportunity for hedging. The volume of trade in futures market is found to be eighteen times higher than spot market (Dash et.al). The market behavior of the selected commodities are analysed using the following tools:

- **Trend Analysis**: Trend analysis is a technical analysis tool to identify whether the market is moving upwards, downwards or sideways.
- **Descriptive Statistics**: It helps to understand the characteristics of the market by giving a summary of data. Measures of central tendency and dispersion like mean and standard deviation helps to understand the average price and variation in prices of variables. The value of skewness and kurtosis helps to identify the asymmetry of the distribution.
- **Coefficient of Variation**: Coefficient of Variation measures the relative standard deviation of the variables. It is the ratio of standard deviation to the mean. The lower the value of CV, better the risk returns trade off.
- **Contango and Backwardation**: Contango is a situation where future prices are more than spot prices of a commodity. Backwardation is a situation where spot prices are more than future prices of a commodity. Contango is when future prices are anticipated to be more than spot prices and backwardation is when future prices is anticipated to be less expensive than spot prices.
- **Compounded Annual Growth Rate**: It is a standard way of visualizing growth of an investment over a period of years.

The results of market behavior analysis of selected commodities in various segments are presented below.

5.1.1 TREND MOVEMENT OF FUTURE AND SPOT PRICES OF COMMODITIES IN BULLION SEGMENT

Chart No: 5.1 Trend Analysis Of Selected Commodities In Bullion Segment



The figure above shows the trend movement of Gold Future and Spot Markets. There was an upward trend in gold prices till 2013 in all markets. The gold prices showed a downward trend till the second half of 2015. A revival of prices was shown from the year 2016. The trend movement of silver shows that the future and spot prices of silver exhibited an increasing trend in the future and spot prices till 2012, after which, the silver prices were seen to have a downward trend.

It can be seen that two markets move in similar pattern which shows a chance of influence of one market over other market. This has to be further probed to know which market reacts first to any new information or shock.

5.1.2 DESCRIPTIVE STATISTICS GROWTH AND INSTABILITY FOR FUTURE AND SPOT PRICES OF COMMODITIES IN BULLION SEGMENT

Descriptive Statistics describes the data in quantitative terms. It gives a summary of sample and the observation made. The summary of statistics is presented in the table no:

Table no: 5.1 Table showing Growth, Instability and Descriptive Statistics of Future and Spot Prices of Commodities in Bullion Segment

	GOLD		SILVER	
	FUTURE	**SPOT**	**FUTURE**	**SPOT**
Mean	22621.153	22620.899	38252.182	37935.499
Maximum	34439	32943	71554	73288
Minimum	8597	8513	15999	16075
Standard Deviation	7247.543	7262.424	13515.218	13309.797
Skewness	-0.508	-0.507	0.086	0.067
Kurtosis	1.785	1.779	1.919	1.914
Coefficient of Variation	32%	32%	35%	35%
CAGR	12.79%	12.78%	9.17%	9.21%
Contango/Backwardation	Contango		Contango	

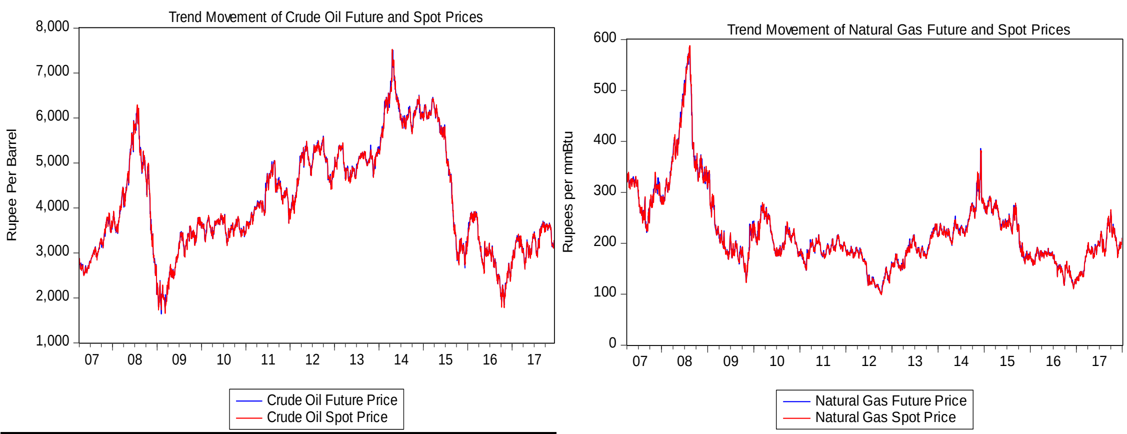
The empirical result reveals that the average gold future price is marginally higher than spot price indicating Contango. The maximum price gold futures during the period were Rs.34439 while minimum price of gold during the period was Rs.8597 with an average gold future price of Rs. 22621.153. Spot prices of gold had a maximum price of Rs.32943 and a minimum price of Rs.8513 with an average price of Rs. 22620.899. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness gold spot and future prices reveals that the series is asymmetrical and negatively skewed. The measure of kurtosis reveals that the series if less peaked and the data is platykurtic.

The empirical result of silver reveals that the average silver future price is greater than spot prices indicating Contango. The maximum price silver futures during the period were Rs.71554 while minimum price of silver during the period was Rs. 15999 with an average silver future price of Rs. 38252.182. Spot prices of silver had a maximum price of Rs. 73288 and a minimum price of Rs. 16075 with an average price of Rs. 37935.499. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness silver spot and future prices reveals that the series is asymmetrical and positively skewed. The measure of kurtosis reveals that the series if less peaked and the data is platykurtic.

The coefficient of variation revealed that the relative variance of Silver future and spot prices are higher than Gold Future and Spot prices. Thus in Bullion segment Silver future and spot prices are more volatile than Gold future and spot prices. The CAGR analysis shows that Gold performed better than silver in the Bullion market segment.

5.1.3 TREND MOVEMENT OF FUTURE AND SPOT PRICES OF COMMODITIES IN ENERGY SEGMENT

Chart No: 5.2 Trend Analysis of Selected Commodities in Energy Segment



The figure above shows the trend movement of Crude oil and Natural Gas future and spot markets. The crude oil and Natural Gas future and spot prices showed an increasing trend till first half of 2008. During the year 2008-09, the future and spot prices of Natural gas and crude oil declined due to global recession, which reduced the demand for crude oil and natural gas. The Crude oil market witnessed a recovery by the end of 2008-09 which was seen increasing trend in future and spot prices till 2014. After 2014, the crude oil prices witnessed a decreasing trend which may be due to increased supply and decreased demand of crude oil. The natural gas futures and spot market witnessed the decreasing trend in prices till 2012-13 due to increased production and inventory levels. A revival of prices of was seen till the middle of 2013-14.The prices of natural gas was shown a downward trend after 2014 because of the oversupply and less demand.

It can be seen that both market move together and the chance of one market influencing other need to be further probed.

5.1.4 DESCRIPTIVE STATISTICS, GROWTH & INSTABILITY FOR FUTURE AND SPOT PRICES OFCOMMODITIES IN ENERGY SEGMENT

Descriptive Statistics describes the data in quantitative terms. It gives a summary of sample and the observation made. The summary of statistics is presented in the table no: 5.2

Table no: 5.2 Table showing Growth, Instability and Descriptive Statistics of Future and Spot Prices of Commodities in Energy Segment

	CRUDE OIL		**NATURAL GAS**	
	FUTURE	**SPOT**	**FUTURE**	**SPOT**
Mean	4156.064	4146.866	222.395	221.537
Maximum	7507	7527	586.5	587.9
Minimum	1641	1656	100.2	99
Standard Deviation	1191.573	1191.312	75.38	75.363
Skewness	0.331	0.325	1.731	1.737
Kurtosis	2.181	2.188	7.281	7.339
Coefficient of Variation	29%	29%	34%	34%
CAGR	-0.26%	-0.34%	-4.79%	-4.77%
Contango/Backwardation	Contango		Contango	

The empirical result reveals that the average Crude oil future price is greater than spot price indicating Contango. The maximum price crude oil futures during the period were Rs. 7507 while minimum price of crude oil during the period was Rs. 1641 with an average crude oil future price of Rs. 4156.064. Spot prices of crude oil had a maximum price of Rs. 7527and a minimum price of Rs. 1656 with an average price of Rs. 4146.866. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness gold spot and future prices reveals that the series is asymmetrical and positively skewed. The measure of kurtosis reveals that the series is less peaked and the data is platykurtic.

The empirical result of natural gas reveals that the average natural gas future price is greater than spot prices indicating Contango. The maximum price natural gas futures during the period were Rs. 586.5 while minimum price of natural gas during the period was Rs. 100.2 with an average natural gas future price of Rs. 222.395. Spot prices of natural gas had a maximum price of Rs. 587.9 and a minimum price of Rs. 99 with an average price of Rs. 221.537. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness silver spot and future prices reveals that the series is asymmetrical and positively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

The coefficient of variation revealed that the relative variance of crude oil future and spot prices are higher than Natural Gas Future and Spot prices. Thus in Energy segment Crude oil future and spot prices are more volatile than natural gas future and spot prices. The CAGR value shows that both the commodities in Energy market have negative growth rate.

5.1.5 TREND MOVEMENT OF FUTURE AND SPOT PRICES OF COMMODITIES IN BASE METALS SEGMENT

Chart No: 5.3 Trend Analysis Of Selected Commodities In Base Metals Segment

From the above chart it can be seen that all the base metals prices dropped in the year 2008-09 due to economic and financial crisis. The base metals or the industrial metals are commonly used in construction and manufacturing industries. With the economic slowdown, there was significant production cuts especially in China, who is the largest consumer of base metals, which made the demand the base metals fell in these years which resulted in a situation of oversupply of these metals. This resulted in a sharp decline in the prices of all the base metals during the year 2009. A revival of prices in Base metals segment was seen after 2010 may be due to the increased production and confidence of investors in the segment. The base metals prices remained somewhat stable till 2014. From the mid 2014, due to decrease in oil consumption and increase in supply globally resulted in fall of oil prices; there was an increase in US Dollar. As this increased the risk of deflation, there was a decrease in global production. This made the prices of base metals to fall after 2014.All the base metals prices showed a revival of prices after 2015 with global economic expansion, and increased demand by Chinese economy. The increasing interest of speculators was reflected in high volatility of prices during this period. With promising investment outlook in this sector by investors and decreasing inventory, made the prices of most of base metals to rise after 2016.

The Aluminum future and spot prices reached the maximum during July 2008 and were found to be at its minimum during February 2009. During the years 2010-13, the aluminum future and spot prices was found to be somewhat stable and averaged around ₹109.A decline of prices was seen in the year 2014-15. The revival of prices was seen during the year 2016-17 and the prices were averaged around ₹113.

The copper future and spot prices was found to be at its peak during September 2013 and its low during December 2008. The copper prices showed an increasing trend after 2011. The copper future and spot prices was found to move sideways during 2012-14 and averaged around ₹410. A downward trend was seen after 2014 in copper prices due to decreased demand and excess supply. A revival of copper future and spot prices was seen in the later half of the year 2016-17 and was averaged to ₹345.

The lead prices were at its maximum during November 2016 and found to be at its lowest during February 2008. The lead prices was shown to have an increasing trend from 2011 and found to be stable during the year 2012-15 averaging to around ₹115. The lead prices were increasing after 2016, and were trading at an average of ₹134.

The maximum Zinc prices were found to be in the month of November 2016 and the minimum Zinc prices was found to be during the month of December 2008. The zinc prices were found to be stable during the years 2010-14. A decreasing trend in Zinc prices was seen after 2014. The revival of zinc prices was seen in the 2016 and the average zinc prices were found to be ₹159 during the year 2016-17.

The Nickel prices were at the highest during the month of April 2007 and were showing a decreasing trend after that. The nickel future and spot prices were at their lowest during December 2008.After an upward trend in prices till 2011; the nickel prices were stable till 2014 with an average of ₹980. After a slight upward trend during 2015, the nickel prices exhibited a downward trend in 2016-17 which may be due to supply disruption from the biggest producers of nickel, Philippines and Indonesia. The average future and spot prices of nickel was found to be around ₹675.

From the trend diagram above it can be seen that the future and spot prices of base metals tend to move together and the chance of one market influencing other due to information shock need to be further probed into.

5.1.6 DESCRIPTIVE STATISTICS, GROWTH& INSTABILITY FOR FUTURE AND SPOT PRICES OFCOMMODITIES IN BASE METALS SEGMENT

Descriptive Statistics describes the data in quantitative terms. It gives a summary of sample and the observation made. The summary of statistics is presented in the table no: 5.3

Table No: 5.3 Table Showing Growth, Instability And Descriptive Statistics Of Future And Spot Prices Of Commodities In Base Metal Segment

	COPPER		**ALUMINIUM**		**ZINC**		**LEAD**		**NICKEL**	
	FUTURE	**SPOT**	**FUTURE**	**SPOT**	**FUTURE**	**SPOT**	**FUTURE**	**SPOT**	**FUTURE**	**SPOT**
Mean	361.85	359.76	106.00	105.28	111.41	110.73	111.72	111.27	924.91	919.86
Maximum	509.95	497.55	142.25	146.6	197.05	199.75	166.85	169.45	2190.2	2259.9
Minimum	141.35	136.95	62.6	62.55	51	49.45	42.3	41.5	455	439.9
SD	69.45	69.04	12.72	12.77	26.10	26.31	20.62	20.83	256.58	259.43
Skewness	-0.77	-0.81	-0.96	-0.94	0.56	0.55	-0.67	-0.65	1.69	1.79
Kurtosis	3.36	3.44	4.59	4.57	3.89	3.91	3.83	3.84	9.31	9.94
CV	19%	19%	12%	12%	23%	23%	18%	18%	28%	28%
CAGR	1.50%	1.47%	0.79%	0.83%	3.45%	3.52%	1.70%	1.69%	-7.47%	-7.45%
Contango/ Backwardation	Contango		Contango		Contango		Contango		Contango	

The descriptive statistics of Copper shows that the average spot price is less than the average future price indicating a Contango. The maximum price Copper futures during the period were ₹509.95 while minimum price of Copper during the period was ₹141.35 with an average Copper future price of ₹361.85. Spot prices of Copper had a maximum price of ₹497.55 and a minimum price of ₹136.95 with an average price of ₹359.76. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness copper spot and future prices reveals that the series is asymmetrical and negatively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

The descriptive statistics of Aluminium shows that the average spot price is less than the average future price indicating a Contango. The maximum price Aluminium futures during the period were ₹142.25 while minimum price of Aluminium during the period was ₹62.6 with an average Aluminium future price of ₹106.00. Spot prices of Aluminum had a maximum price of ₹146.6 and a minimum price of ₹ 62.55 with an average price of ₹105.28. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness Aluminium spot and future prices reveals that the series is asymmetrical and negatively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

The descriptive statistics of Zinc shows that the average spot price is less than the average future price indicating a Contango. The maximum price Zinc futures during the period were ₹197.05 while minimum price of Zinc during the period was ₹51 with an average Zinc future price of ₹111.41. Spot prices of Zinc had a maximum price of ₹199.75 and a minimum price of ₹ 49.45 with an average price of ₹110.73. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness Zinc spot and future prices reveals that the series is asymmetrical and positively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

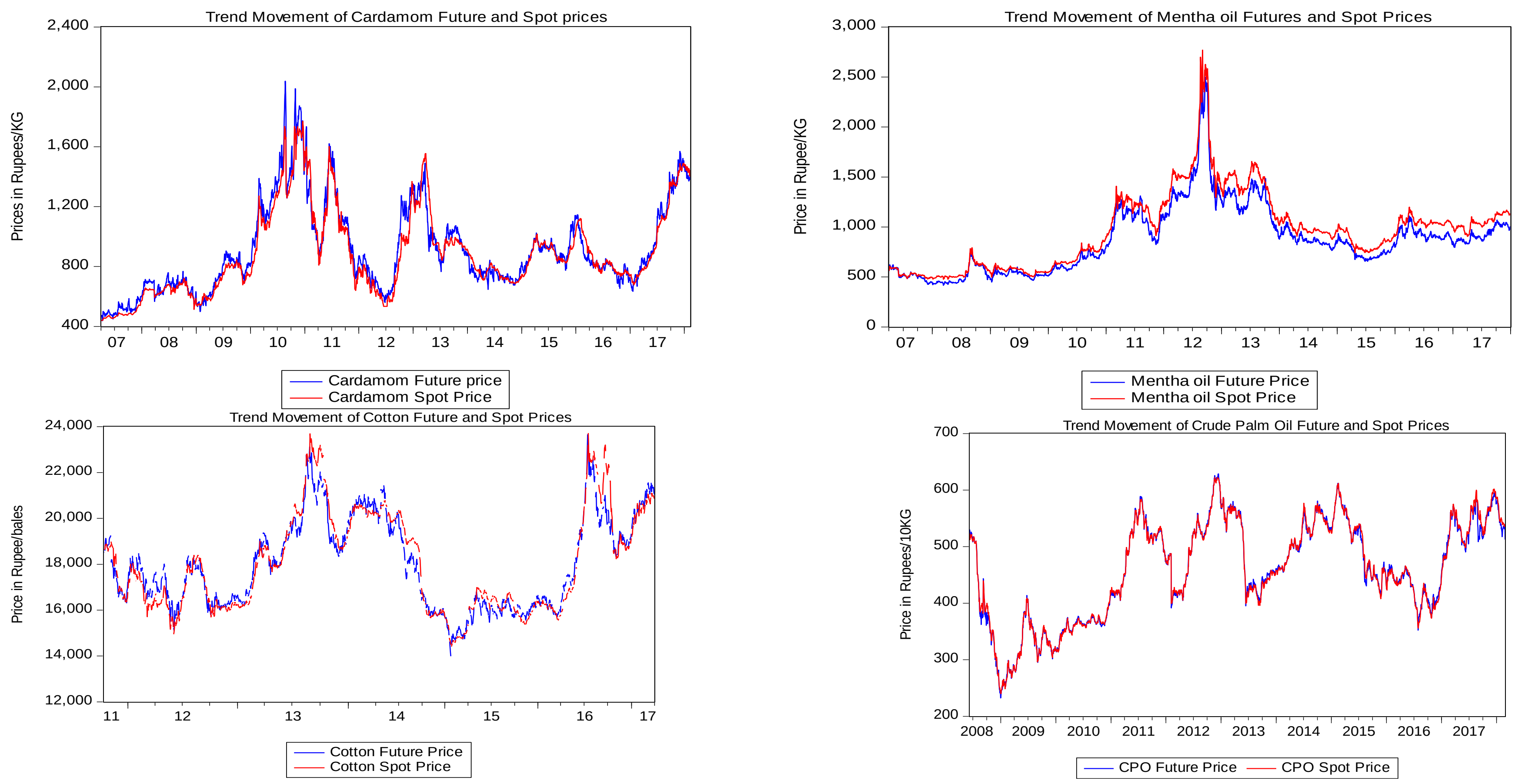
The descriptive statistics of Lead shows that the average spot price is less than the average future price indicating a Contango. The maximum price Lead futures during the period were ₹166.85 while minimum price of Lead during the period was ₹42.3 with an average Lead future price of ₹111.72. Spot prices of Lead had a maximum price of ₹169.45 and a minimum price of ₹ 41.5 with an average price of ₹111.27. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness Lead spot and future prices reveals that the series is asymmetrical and negatively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

The descriptive statistics of Nickel shows that the average spot price is less than the average future price indicating a Contango. The maximum price Nickel futures during the period were ₹2190.2 while minimum price of Nickel during the period was ₹ 455 with an average Nickel future price of ₹924.91. Spot prices of Nickel had a maximum price of ₹2259.9 and a minimum price of ₹439.9 with an average price of ₹919.86. The high value of standard deviation also reveals the non stability of prices. The analysis of skewness Nickel spot and future prices reveals that the series is asymmetrical and positively skewed. The measure of kurtosis reveals that the series if more peaked and the data is leptokurtic.

The coefficient of variation of Commodities in Base Metals reveals that Nickel is relatively more variable followed by Zinc. Aluminium is found to be relatively less volatile compared to all other commodities in the same segment. The CAGR analysis of Base metal segment showed that Zinc have the highest growth rate of 3.45% where as nickel have a negative growth rate of -7.45%.

5.1.7 TREND MOVEMENT OF FUTURE AND SPOT PRICES OF COMMODITIES IN AGRICULTURAL COMMODITIES SEGMENT

Chart No: 5.4 Chart Showing Trend Movement Of Future And Spot Prices Of Agricultural Commodities



5.1.8 DESCRIPTIVE STATISTICS, GROWTH& INSTABILITY FOR FUTURE AND SPOT PRICES OFCOMMODITIES IN AGRICULTURAL COMMODITIES SEGMENT

Table No: 5.4 Table Showing Growth, Instability And Descriptive Statistics Of Future And Spot Prices Of Commodities In Agricultural Commodities Segment

	CARDAMOM		MENTHA OIL		CRUDE PALM OIL		COTTON	
	FUTURE	**SPOT**	**FUTURE**	**SPOT**	**FUTURE**	**SPOT**	**FUTURE**	**SPOT**
Mean	911.03	886.50	872.41	966.14	459.20	459.55	17996.6	18041.83
Maximum	2038.2	1770	2499.2	2769.3	628.7	622.3	23650	23720
Minimum	437.8	437.1	416.2	477.1	232.3	240	13990	14420
SD	289.98	283.69	335.54	376.87	86.76	87.32	1950.35	2150.70
Skewness	0.96	0.88	1.33	1.12	-0.34	-0.32	0.43	0.55
Kurtosis	3.57	3.26	6.30	5.33	2.22	2.18	2.16	2.30
CV	31%	32%	38%	39%	19%	19%	11%	12%
CAGR	8.45%	9%	7.55%	8.32%	6.44%	5.63%	2.99%	3.74%
Contango/ Backwardation	Contango		Backwardation		Backwardation		Backwardation	

From the trend analysis it can be seen cardamom prices peaked during 2010 and continued to increase till January 2011. The maximum cardamom prices were seen during the month of October 2010. The prices of cardamom were seen to be declining since then. The average prices of cardamom during the year 2016-17 were found to be ₹1150.

An analysis of Mentha oil Futures and spot prices shows that the prices were almost stable till 2010. The prices were found to be increasing due to increased export demand. The maximum prices of mentha oil were found to be during the month of March 2012. The prices of mentha oil were found to be decreasing since then due decreased industrial demand and increased stock positions in Chadaousi, Uttar Pradesh. The average prices of mentha oil during the year 2016-17 were found to be around ₹980.

The trend analysis of cotton futures and spot prices showed a decreasing trend in the year 2011-12, which may be mainly due to the ban of export of cotton which led to a loss of opportunity of farmers to sell the produce at a good price. Later with the removal of export ban, the cotton prices were found to have an increasing trend. A sharp decline in copper future and spot prices was seen during 2014-15 with steep fall in export to china which led to excess supply of cotton. The year 2016-17 witnessed increased export to other countries like Vietnam, where an export deal of $300 million which includes cotton yarn was signed. This made the prices of Cotton to go up during that period. The maximum cotton prices were during the month of July 2016 and minimum during the month of January 2015. The average future and spot price of cotton during the year 2016-17 was found to be around ₹19700/bale.

The coefficient of variation of Agricultural commodities reveals that Mentha Oil is relatively more variable followed by Cardamom. Cotton is found to be relatively less volatile compared to all other commodities in the same segment. The CAGR analysis of Agricultural Commodities showed that Cardamom have the highest growth rate of around 9% followed by mentha oil.

5.2 TO ANALYSE THE IMPACT OF SELECTED MACROECONOMIC VARIABLES ON COMMODITY FUTURES MARKET

The impact of macroeconomic variables on commodity prices is analysed using regression analysis. Log values of monthly averages of the commodity future prices are used in the study. The macro economic variables selected for the study are taken based upon the theoretical importance. The variables selected for the study are: Index of Industrial Production (IIP), Exchange Rate (EX), Wholesale Price Index (WPI) and stock exchange index, (NIFTY).

To measure an economic activity of the country, GDP is the obvious choice. Since GDP is announced quarterly, this cannot be used in the study as all others variables are taken monthly. Hence Index of Industrial production is used as a proxy to GDP. Index of Industrial production is announced monthly and display strong co-movement with GDP. So this study uses Index of Industrial production (IIP) measures the growth rate of real industrial sector with base year of 2004-05. With most of the commodities traded in US Dollar, the changes in exchange rate between Indian Rupee and US Dollar definitely impacts the commodity prices. Hence exchange rates of US dollar to Indian Rupee have been taken into consideration. Commodities are also considered as a hedge against inflation. When many asset class prices decrease due to inflation, commodities prices tend to increase at the time of inflation. Hence commodities are considered to be best to preserve the real purchasing power. In India, three different price indices are available to measure inflation: Wholesale Price Index (WPI), Consumer Price Index (CPI) and GDP Inflator. This study uses Wholesale Price Index (Base year-2004-05) as a proxy to measure inflation as it has a broader coverage and is also published in more frequent and timely manner. Commodities are often used as a diversification tool. Commodities are often negatively correlated with stocks, which mean that when stock prices go down, commodity prices go up. This study uses NIFTY 50 as a proxy for stock prices which is a well diversified portfolio of 50 stocks of 25 sectors.

The variables are converted into logarithmic forms to minimize the heteroscedasticity of the variables. Since a time series is subject to spurious regression if the data are non-stationary, unit root test is applied to check the stationarity of data. If the series is found to be non stationary at levels, they are converted into first difference to make it stationary. Further, stepwise regression is used in the study to avoid problems of multicollinearity among the independent variables.

5.2.1 STATIONARITY TEST OF MONTHLY COMMODITY FUTURES AVERAGE AND SELECTED MACROECONOMIC INDICATORS

Before doing regression analysis, it is important to convert the data into stationary variables to avoid spurious regression. Hence, Augmented Dickey Fuller test has been applied to check the stationarity of the variables. The results are presented in the table below:

Table no: 5.5 Results of ADF test for commodity futures and Macroeconomic Variables

Name of Variable	Level	First Difference
LIIP	-1.274	-4.436***
LWPI	-1.720	-6.134***
LEX	-1.178	-8.145***
LNIFTY	-1.139	-10.252***
LGold_monthly	-2.730	-12.842***
LSilver_monthly	-1.746	-11.071***
LCrude_monthly	-2.704	-8.175***
LNatural Gas_monthly	-2.414	-9.715***
LCopper_monthly	-1.885	-5.919***
LAluminium_monthly	-2.433	-10.486***
LZinc_monthly	-1.475	-12.606***
LLead_monthly	-2.454	-11.367***
LNickel _monthly	-1.765	-10.140***
LCardamom_monthly	-2.413	-9.564***
LMentha Oil_monthly	-1.669	-10.236***
LCPO_monthly	-2.699	-4.992***
LCotton_monthly	-2.257	-10.166***

From the table above it can be seen that the variables are stationary at first difference. Hence to do the regression analysis, the variables in their first difference are used. Following is the regression equation framed for the analysis.

$$Dlog\ (Comm\_fut_{\ i\ldots n})_t = \alpha_1 + \beta_1 Dlog(IIP)_t + \beta_2 Dlog(WPI) + \beta_3 Dlog(EX) + \beta_4 Dlog(NIFTY)$$

Where Comm_fut are the selected 13 commodities futures considered for the study.

5.2.2 MULTIVARIATE STEPWISE REGRESSION

In the analysis, Multivariate stepwise regression has been used to avoid the problem of multicollinerarity. The results of the Multivariate stepwise regression are presented in the Table No: 5.6.

From the table it can be seen that only those variables which significantly impact the commodity future prices are included in the model and all other variables are excluded from the model. The analysis reveals that there is a significant positive impact of WPI on futures prices of Silver, Crude Oil, Natural Gas, Copper, Aluminium, Zinc, Nickel and Copper. This reveals that investment in these commodity futures will act as a hedge against inflation. The exchange rate is found to have a negative impact on Nickel and mentha oil future prices. Thus, with the increase in exchange rates by 1% there is a decrease in price of nickel and mentha oil by 128% and 91% respectively. The IIP is found to have a negative impact on gold prices and positive impact on zinc prices. Thus with the increase in 1% IIP, the future prices of gold decreases by 17% and Zinc futures prices increases by 26%. Nifty is found to have a positive impact on cardamom prices and negative impact on Crude palm Oil prices. Thus with 1% increase in nifty causes an increase in cardamom prices by 29% and decrease in CPO prices by 22%.

The r squared value of all the regression models is found to be significant. The autocorrelation have been checked using Durbin Watson and it was found that there is no auto correlation in the model. The normality of the residuals is checked using Jacque bera test. The null hypothesis is not rejected in all the cases, hence it is concluded that the residuals of the model are normally distributed. Thus, this model is found to be fit.

Table No: 5.6 Results of Stepwise Regression of Selected Commodities and Selected Macroeconomic Variables

	c	IIP	WPI	NIFTY	EX	R^2	Adj.R^2	DW	JB
Gold	0.010	-0.168***	-	-	-	0.135***	0.127***	2.2	1.17
Silver	0.005	-	1.854**	-	-	0.179***	0.163***	2.05	0.70
Crude	-0.010	-	3.101***	-	-	0.284***	0.268***	1.92	3.87
Natural Gas	-0.014	-	2.522*	-	-	0.127*	0.119*	1.89	8.94
Copper	0.002	-	2.471***	-	-	0.164***	0.150***	2.02	3.34
Aluminium	-0.007	-	1.911***	-	-	0.133***	0.118***	2.15	0.06
Zinc	0.000	0.259***	0.319***	-	-	0.192***	0.177***	2.33	3.05
Lead	0.004	-	1.607***	-	-	0.146***	0.131***	2.14	0.22
Nickel	-0.014	-	2.249***	-	-1.280***	0.110***	0.095***	1.97	3.50
Cardamom	0.007	-	-	0.286*	-	0.127**	0.118**	1.79	3.87
Mentha Oil	0.007	-	-	-	-0.907**	0.128**	0.119**	1.82	3.65
CPO	-0.002			-0.218**		0.136**	0.127**	1.68	2.67
Cotton	0.003		1.861*			0.157*	0.142*	2.19	1.32

***refers to significance at 1% significance level.

**refers to significance at 5%level.

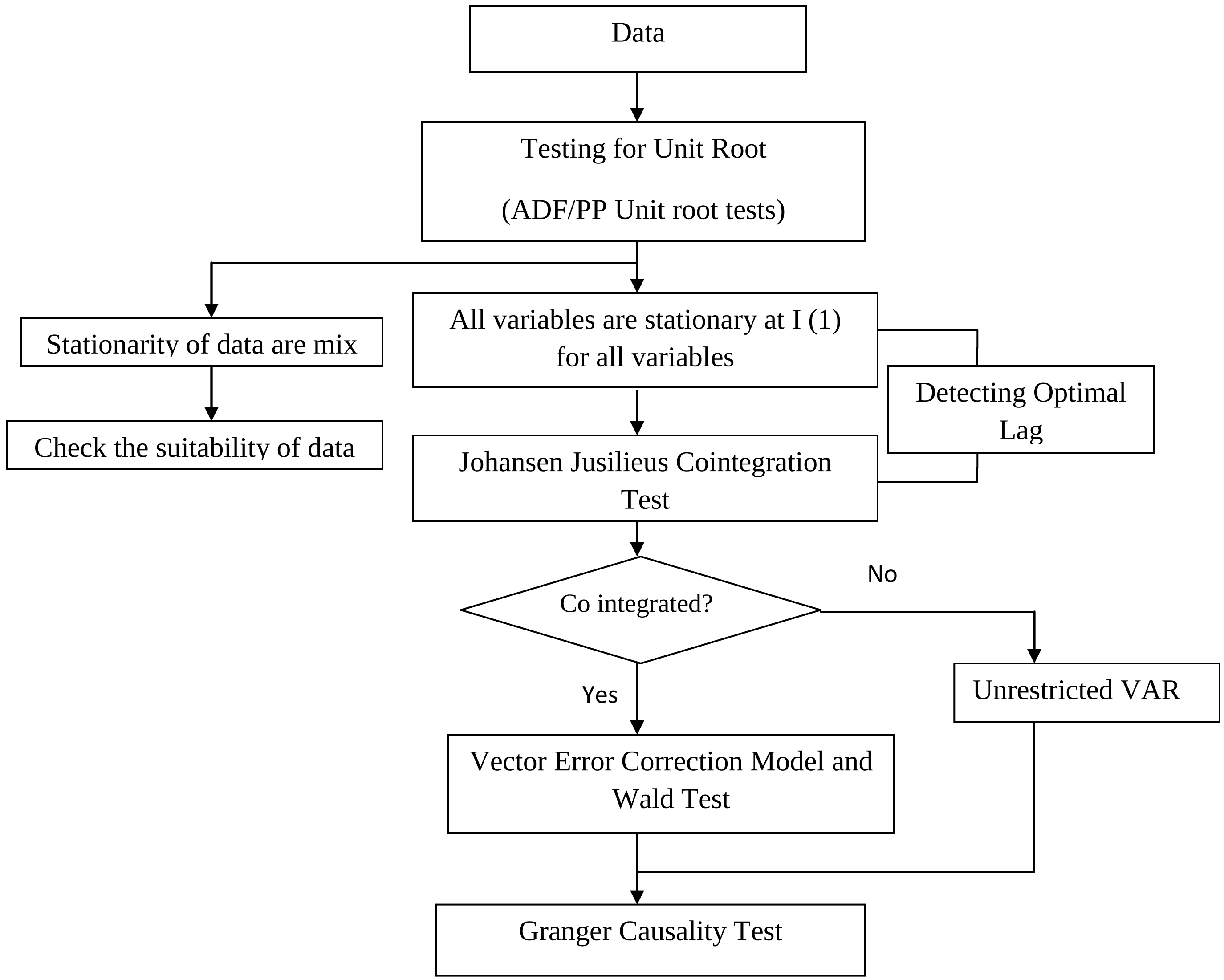
*refers to significance at 10% level

5.3 TO ANALYSE THE PRICE DISCOVERY PROCESS OF INDIAN COMMODITY SPOT AND FUTURES MARKET

Price discovery refers to the process by which market converge to the efficient price of the underlying asset. At the time of any new information which is arrived in the market, the market which is efficient absorbs the information first, which is then transmitted to the other market. The re adjustment occurs until the equilibrium is achieved. When the information is arrived for the same asset in two markets, both markets should react in a similar manner. If the reaction of market is differs, one market will lead the other market. In such a case of lead lag relationship, the market which is leading does the price discovery function.

The price discovery process of Indian Commodity futures and spot market is analysed using Johansen and Juselius Cointegration analysis and Vector Error Correction model. The stationarity of the series is checked using Augmented Dickey Fuller Test and Philips Perron test. After confirming stationarity at first difference, the Johansen and Juselius cointegration analysis is used to analyse the long run equilibrium relationship between the spot and futures market. If future and spot markets are found to be cointegrated, it is then represented through an Error Correction Model that shows the speed of adjustment in case both the series deviate from equilibrium in short run. When futures and spot market are found to be cointegrated, the causality should be present at least in one direction. The cointegrating vectors represent the long run equilibrium, while error correction mechanism describes the price discovery process, where market try to attain equilibrium in case of any deviation in short run. After confirming the cointegration that confirms causality in at least one direction, granger causality test is performed to understand the lead lag relationship between future and spot market.

The steps in analyzing the price discovery process can be represented through the following diagram:


Data
Testing for Unit Root
(ADF/PP Unit root tests)
Stationarity of data are mix
Check the suitability of data
All variables are stationary at I (1) for all variables
Detecting Optimal Lag
Johansen Jusilieus Cointegration Test
Co integrated?
No
Yes
Unrestricted VAR
Vector Error Correction Model and Wald Test
Granger Causality Test

5.3.1 PRICE DISCOVERY OF GOLD FUTURES AND SPOT MARKET

5.3.1.1 STATIONARITY TEST FOR GOLD FUTURE AND SPOT PRICES

The gold futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{1.1}$: *The future and spot prices of gold are not stationary*

Table No: 5.7 Result of Stationarity test of Gold Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-2.159	-52.956*	-2.044	-52.864*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.132	-52.990*	-2.032	-52.878*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Gold Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices are found to be stationary at first difference and are integrated in the order of one.

5.3.1.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR GOLD FUTURE AND SPOT PRICES

After confirming the stationarity of gold futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{1.2}$: There is no cointegration between future and spot prices of gold

Table No: 5.8 Results of Johansen's Cointegration Analysis of Gold Spot and Future Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	76.358*	71.738*	25.872	19.387	Cointegrated
H_1 r=1	4.620	4.620	12.517	12.517	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of four lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (76.358) and Maximum Eigen value(λ_{max}) (71.738) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (4.620) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.1.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR GOLD FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of gold, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows:

$H_0^{1.3}$: There is no Long run causality between Future and Spot prices of gold

$H_0^{1.4}$: There is no Short run causality between Future and Spot prices of gold

Table No: 5.9 Results of Vector Error Correction Model and Wald Test for Gold spot and Future prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.074	0.000	-0.053	0.011
ΔS_{t-1}	-0.515	0.000	0.030	0.395
ΔS_{t-2}	-0.251	0.000	0.041	0.285
ΔS_{t-3}	-0.113	0.000	0.038	0.300
ΔS_{t-4}	-0.031	0.091	-0.036	0.154
ΔF_{t-1}	0.685	0.000	0.007	0.826
ΔF_{t-2}	0.341	0.000	-0.050	0.170
ΔF_{t-3}	0.156	0.000	-0.017	0.637
ΔF_{t-4}	0.082	0.004	0.036	0.242
c	0.027	0.068	0.038	0.054
Wald Test for short run causality(Chi-square and P.Value)	987.977 (0.000)		6.054 (0.195)	

correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation

(-0.074) and for Future equation (-0.053). The spot equation reveals that about 7% of disequilibrium is corrected by spot prices everyday as compared to 5% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till 3rd lag and are also influenced by futures till fourth lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market. This implies that when there is any deviation from cost of carry relationship, spot prices makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of gold. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero indicating short run causality running from future to spot market. On the other hand, in future equation, the cross terms are found to be simultaneously zero, indicating the absence of short run causality from spot to future market.

Thus a clear dominance of future market in price discovery can be seen from the results of Vector Error Correction Model and Wald Test for Gold. Thus the null hypothesis is rejected and a long run and short run causality is found between gold futures and spot market. So it is inferred that future market is more efficient in absorbing new information which is reflected into prices than spot market, and hedgers can use future market as base for effective hedging strategies.

5.3.1.4 GRANGER CAUSALITY TEST FOR GOLD FUTURE AND SPOT PRICES

Granger Causality test is performed on the gold Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{1.5}$: There is no lead lag relationship between Gold Spot and Future prices of Gold

Table No: 5.10 Result of Granger Causality Test for Gold Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Gold Spot price does not granger cause Gold Future Price	2.046	0.130	Uni Directional
Gold Future price does not granger cause Gold Spot Price	836.203	0.000	

From the above table, it can be seen that probability value of null hypothesis "Gold spot price does not granger cause Gold future price" is more than 5% significance level. So it is inferred that there is no lead lag relationship from spot to future. The null hypothesis "Gold future price does not granger cause Gold spot price" is less than the 5% significance level, hence we can the reject the null hypothesis and it can be inferred that there is a uni directional relationship between future and spot prices. This shows the dominance of future market and past values of future prices can be used to predict future spot prices.

The results of the study concurs with the study of Kumar and Arora (2010), Shihabudheen and Padhi (2010), Saranya (2014) , Zhang (2015), Jin et.al. (2016) but differs from the study of Srinivasan and Ibrahim (2012) and Sehgal et.al (2013), Joshy and Ganesh (2015).

5.3.2 PRICE DISCOVERY OF SILVER FUTURES AND SPOT MARKET

5.3.2.1 STATIONARITY TEST FOR SILVER FUTURE AND SPOT PRICES

The Silver futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{2.1}$: The future and spot prices of silver are not stationary

Table No: 5.11 Result of Stationarity test of Silver Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.631	-54.641*	-1.649	-54.786*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-1.620	-54.611*	-1.646	-54.745*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Silver Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of silver are found to be stationary at first difference and are integrated in the order of one.

5.3.2.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR SILVER FUTURE AND SPOT PRICES

After confirming the stationarity of Silver futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{2.2}$*: There is no cointegration between future and spot prices of Silver*

Table No: 5.12 Results of Johansen's Cointegration Analysis of Silver Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	133.422	130.802	25.872	19.387	Cointegrated
H_1 r=1	2.621	2.621	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of six lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (133.422) and Maximum Eigen value(λ_{max}) (130.802) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (2.621) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of silver tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.2.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR SILVER FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Silver, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows:

$H_0^{2.3}$*: There is no Long run causality between Future and Spot prices of Silver*

$H_0^{2.4}$*: There is no Short run causality between Future and Spot prices of Silver*

Table No: 5.13 Results of Vector Error Correction Model and Wald Test for Silver Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.173) and for Future equation (-0. 128) of silver. The spot equation reveals that about 17% of disequilibrium is corrected by spot prices everyday as compared to 12% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till 6th lag and are also influenced by futures till fifth lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of silver, it can be inferred than even though there is bidirectional causality between the spot and

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.173	0.000	-0.128	0.003
ΔS_{t-1}	-0.463	0.000	-0.006	0.872
ΔS_{t-2}	-0.330	0.000	-0.025	0.558
ΔS_{t-3}	-0.222	0.000	-0.032	0.455
ΔS_{t-4}	-0.169	0.000	-0.040	0.319
ΔS_{t-5}	-0.074	0.005	0.021	0.542
ΔS_{t-6}	-0.037	0.042	0.008	0.744
ΔF_{t-1}	0.570	0.000	0.032	0.396
ΔF_{t-2}	0.342	0.000	0.011	0.786
ΔF_{t-3}	0.248	0.000	0.043	0.301
ΔF_{t-4}	0.195	0.000	0.079	0.047
ΔF_{t-5}	0.121	0.000	-0.003	0.942
ΔF_{t-6}	0.035	0.118	0.038	0.206
c	0.0002	0.366	0.0002	0.461
Wald Test for short run causality(Chi-square & P.Value)	435.163 (0.000)		3.564 (0.735)	

future market, the long run causality effect is more from future to spot market for Silver. This implies that when there is any deviation from cost of carry relationship, spot prices of silver makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Silver. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero indicating short run causality running from future to spot market of Silver. On the other hand, in future equation, the cross terms are found to be simultaneously zero, indicating the absence of short run causality from spot to future market for Silver.

Thus a clear dominance of future market in price discovery can be seen from the results of Vector Error Correction Model and Wald Test of Silver. Thus the null hypothesis is rejected and a long run and short run causality is found between Silver futures and spot market.

5.3.2.4 GRANGER CAUSALITY TEST FOR SILVER FUTURE AND SPOT PRICES

Granger Causality test is performed on the Silver Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{2.5}$*: There is no lead lag relationship between Spot and Future prices of Silver*

Table No: 5.14 Result of Granger Causality Test for Silver Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Silver Spot price does not granger cause Silver Future Price	2.018	0.059	Uni Directional
Silver Future price does not granger cause Silver Spot Price	302.969	0.000	

From the above table, it can be seen that probability value of null hypothesis "Silver spot price does not granger cause Silver future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Silver spot prices cannot be used to predict Silver future prices. The probability value of null hypothesis "Silver Future price does not granger cause Silver Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Silver can be used to predict future Silver spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Silver during this period. This shows a clear evidence of domination of future market compared to spot market in Silver, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Silver market, future market leads and spot market follows.

The findings of the study concurs with the study of Garabde and Silber(1983), Shihabhudheen and Padhi (2010), Saranya (2014), Harper et.al; (2015), Babu and Srinivasan (2017) but differs from the study of Sridhar et.al; (2016), Sehgal et.al.(2013)

5.3.3 PRICE DISCOVERY OF CRUDE OIL FUTURES AND SPOT MARKET

5.3.3.1 STATIONARITY TEST FOR CRUDE OIL FUTURE AND SPOT PRICES

The Crude Oil futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{3.1}$: The future and spot prices of Crude Oil are not stationary

Table No: 5.15 Result of Stationarity test of Crude Oil Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.970	-58.995*	-1.987	-53.039*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579

Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.027	-58.996*	-1.957	-53.050*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Crude Oil Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Crude Oil are found to be stationary at first difference and are integrated in the order of one.

5.3.3.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR CRUDE OIL FUTURE AND SPOT PRICES

After confirming the stationarity of Crude Oil futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{3.2}$: There is no cointegration between future and spot prices of Crude Oil

Table No: 5.16 Results of Johansen's Cointegration Analysis of Crude Oil Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	705.012	700.716	25.872	19.387	Cointegrated
H_1 r=1	4.296	4.296	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (705.012) and Maximum Eigen value(λ_{max}) (700.716) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (4.296) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Crude Oil tend to move together in long run and any shocks which affects the equilibrium gets

	Δ Spot	***Δ Future***

corrected over time.

5.3.3.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR CRUDE OIL FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Crude Oil, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{3.3}$: *There is no Long run causality between Future and Spot prices of Crude Oil*

$H_0^{3.4}$: *There is no Short run causality between Future and Spot prices of Crude Oil*

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.703	0.000	-0.103	0.014
ΔS_{t-1}	-0.116	0.000	0.011	0.751
ΔS_{t-2}	-0.006	0.700	0.004	0.868
ΔF_{t-1}	0.242	0.000	0.056	0.164
ΔF_{t-2}	0.063	0.008	-0.053	0.100
c	0.008	0.870	0.005	0.879
Wald Test for short run causality(Chi-square and P.Value)	74.161 (0.000)		0.108 (0.951)	

Table No: 5.17 Results of Vector Error Correction Model and Wald Test for Crude Oil Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.703) and for Future equation (-0.103) of Crude Oil. The spot equation reveals that about 70% of disequilibrium is corrected by spot prices everyday as compared to 10% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till 1st lag and are also influenced by futures till second lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of Crude Oil, it can be inferred than even though there is bidirectional long run causality between the spot and future market, the long run causality effect is more from future to spot market for Crude Oil. This implies that when there is any deviation from cost of carry relationship, spot prices of Crude Oil makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Crude Oil. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero whereas in future equation, it was found to be insignificant. This indicates uni directional short run causality running between future and spot market of Crude Oil.

Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration Test, Vector Error Correction Model and Wald Test of Crude Oil. Thus the null hypothesis is rejected and a long run and short run causality is found between Crude Oil futures and spot market.

5.3.3.4 GRANGER CAUSALITY TEST FOR CRUDE OIL FUTURE AND SPOT PRICES

Granger Causality test is performed on the Crude Oil Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{2.5}$: There is no lead lag relationship between Spot and Future prices of Crude Oil

Table No: 5.18 Result of Granger Causality Test for Crude Oil Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Crude Oil Spot price does not granger cause Crude Oil Future Price	2.290	0.102	Uni Directional
Crude Oil Future price does not granger cause Crude Oil Spot Price	2053.359	0.000	

From the above table, it can be seen that probability value of null hypothesis "Crude Oil spot price does not granger cause Crude Oil future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Crude oil spot prices cannot be used to predict Crude oil future prices. The probability value of null hypothesis "Crude oil Future price does not granger cause Crude oil Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Crude Oil can be used to predict future Crude oil spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Crude oil during this period. This shows a clear evidence of domination of future market compared to spot market in Crude oil, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Crude oil market, future market leads and spot market follows.

The findings of the study concurs with the study of Elder et.al;(2014), Mehrara and Hamldar (2014), Feng et.al;(2014), Babu and Srinivasan (2017) but differs from the study of Goyal and Tripathi (2012).

5.3.4 PRICE DISCOVERY OF NATURAL GAS FUTURES AND SPOT MARKET

5.3.4.1 STATIONARITY TEST FOR NATURAL GAS FUTURE AND SPOT PRICES

The Natural Gas futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{4.1}$: The future and spot prices of Natural Gas are not stationary

Table No: 5.19 Result of Stationarity test of Natural Gas Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-2.782	-55.786*	-2.692	-53.710*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.646	-55.890*	-2.640	-53.709*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Natural Gas Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Natural Gas are found to be stationary at first difference and are integrated in the order of one.

5.3.4.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR NATURAL GAS FUTURE AND SPOT PRICES

After confirming the stationarity of Natural Gas futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{4.2}$: There is no cointegration between future and spot prices of Natural Gas

Table No: 5.20 Results of Johansen's Cointegration Analysis of Natural Gas Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	1370.753	1363.213	25.872	19.387	Cointegrated
H_1 r=1	7.540	7.540	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of one lag has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (1370.753) and Maximum Eigen value(λ_{max}) (1363.213) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (7.540) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Natural Gas tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.4.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR NATURAL GAS FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Natural Gas, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{4.3}$: There is no Long run causality between Future and Spot prices of Natural Gas

$H_0^{4.4}$: There is no Short run causality between Future and Spot prices of Natural Gas

Table No: 5.21 Results of Vector Error Correction Model and Wald Test for Natural Gas Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.853) and not significant for Future equation (-0.044) of Natural Gas. The spot equation reveals that about 85% of disequilibrium is corrected by spot prices every day. The error correction estimates shows that spot prices are not affected by its own lags and are influenced by futures till first lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is significant and negative only in spot equation, it can be inferred that there is unidirectional long run causality between the spot and future market. This implies that when there is any deviation from cost of carry relationship, spot prices of Natural Gas makes adjustment to re-establish equilibrium.

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.853	0.000	-0.044	0.233
ΔS_{t-1}	-0.016	0.202	-0.006	0.760
ΔF_{t-1}	0.051	0.020	0.019	0.587
c	-0.001	0.621	-0.005	0.765
Wald Test for short run causality(Chi-square and P.Value)	5.438 (0.019)		0.093 (0.760)	

Wald test is performed to analyse the short run dynamics between future and spot prices of Natural Gas. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero whereas in future equation, it was found to be insignificant. This indicates uni directional short run causality running between future and spot market of Natural Gas.

Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration Test, Vector Error Correction Model and Wald Test of Natural Gas. Thus the null hypothesis is rejected and a long run and short run causality is found between Natural Gas futures and spot market.

5.3.4.4 GRANGER CAUSALITY TEST FOR NATURAL GAS FUTURE AND SPOT PRICES

Granger Causality test is performed on the Natural Gas Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{4.5}$: There is no lead lag relationship between Spot and Future prices of Natural Gas

Table No: 5.22 Result of Granger Causality Test for Natural Gas Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Natural Gas Spot price does not granger cause Natural Gas Future Price	0.054	0.815	Uni Directional
Natural Gas Future price does not granger cause Natural Gas Spot Price	2266.501	0.000	

From the above table, it can be seen that probability value of null hypothesis “Natural Gas spot price does not granger cause Natural Gas future price” is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Natural Gas spot prices cannot be used to predict Natural Gas future prices. The probability value of null hypothesis “Natural Gas Future price does not granger cause Natural Gas Spot price” is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Natural Gas can be used to predict future Natural Gas spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Natural Gas during this period. This shows a clear evidence of domination of future market compared to spot market in Natural Gas, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Natural Gas market, future market leads and spot market follows.

The findings of the study concurs from the study of Behera(2015),Chen et.al (2017), Babu and Srinivasan (2017) but differs from the study of Chinn et.al; (2005), Zhang and Liu(2018)

5.3.5 PRICE DISCOVERY OF COPPER FUTURES AND SPOT MARKET

5.3.5.1 STATIONARITY TEST FOR COPPER FUTURE AND SPOT PRICES

The Copper futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{5.1}$: *The future and spot prices of Copper are not stationary*

Table No: 5.23 Result of Stationarity test of Copper Spot and Future Prices

	Spot		Future	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.915	-58.066*	-1.858	-53.714*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-1.970	-58.009*	-1.933	-53.732*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Copper Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Copper are found to be stationary at first difference and are integrated in the order of one.

5.3.5.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR COPPER FUTURE AND SPOT PRICES

After confirming the stationarity of Copper futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{5.2}$: *There is no cointegration between future and spot prices of Copper*

Table No: 5.24 Results of Johansen's Cointegration Analysis of Copper Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	231.483	226.801	25.872	19.387	Cointegrated
H_1 r=1	4.682	4.682	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of five lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (231.483) and Maximum Eigen value(λ_{max}) (226.801) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (4.682) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Copper tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.5.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR COPPER FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Copper, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows:

$H_0^{5.3}$: There is no Long run causality between Future and Spot prices of Copper

$H_0^{5.4}$: There is no Short run causality between Future and Spot prices of Copper

Table No: 5.25 Results of Vector Error Correction Model and Wald Test for Copper Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.305) and for Future equation (-0. 179) of copper. The spot equation reveals that about 31% of disequilibrium is corrected by spot prices everyday as compared to 18% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till 4th lag and are also influenced by futures till fifth lag. The future prices are influenced by any of its own lag till 4th lag and spot prices till second lag. Since the coefficient of error correction term is higher in magnitude in spot equation than the future

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.305	0.000	-0.179	0.000
ΔS_{t-1}	-0.388	0.000	-0.115	0.005
ΔS_{t-2}	-0.263	0.000	-0.161	0.001
ΔS_{t-3}	-0.168	0.000	-0.070	0.065
ΔS_{t-4}	-0.111	0.000	-0.084	0.069
ΔS_{t-5}	-0.008	0.518	-0.035	0.085
ΔF_{t-1}	0.655	0.000	0.146	0.003
ΔF_{t-2}	0.374	0.000	0.126	0.007
ΔF_{t-3}	0.271	0.000	0.166	0.001
ΔF_{t-4}	0.189	0.000	0.095	0.016
ΔF_{t-5}	0.107	0.000	0.051	0.127
c	0.001	0.930	0.005	0.851
Wald Test for short run causality(Chi-square and P.Value)	600.621 (0.000)		20.291 (0.001)	

equation of copper, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market for copper. This implies that when there is any deviation from cost of carry relationship, spot prices of copper makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Copper. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in both cases, coefficients are significantly different from zero indicating bi directional short run causality running between future and spot market of Copper. Since the magnitude of chi-square is found to be higher in spot equation than future equation, , it can be inferred than even though there is bidirectional short run causality between the spot and future market, the short run causality effect is more from future to spot market for copper.

Thus a clear dominance of future market in price discovery can be seen from the results of Vector Error Correction Model and Wald Test of Copper. Thus the null hypothesis is rejected and a long run and short run causality is found between copper futures and spot market.

5.3.5.4 GRANGER CAUSALITY TEST FOR COPPER FUTURE AND SPOT PRICES

Granger Causality test is performed on the Copper Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{5.5}$: There is no lead lag relationship between Spot and Future prices of Copper

Table No: 5.26 Result of Granger Causality Test for Copper Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Copper Spot price does not granger	3.324	0.003	Bi

cause Copper Future Price			Directional
Copper Future price does not granger cause Copper Spot Price	872.646	0.000	

From the above table, it can be seen that probability value of null hypothesis "Copper spot price does not granger cause Copper future price" and "Copper Future price does not granger cause Copper Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Copper can be used to predict future Copper spot prices and vice versa. Thus it is concluded that there is a bidirectional causal relationship from future to spot market for Copper during this period. As the coefficient of "future prices does not granger causes spot prices" is higher in magnitude it shows a domination of future market compared to spot market in Copper, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Copper market, future market leads and spot market follows.

The findings of the study concurs with the study of Garabde and Silber(1983), Fu and Qing (2006), Figuerola and Gonzalo(2012), Saranya(2014), Velmurugan et.al;(2015), but differs from the study of Kenourgious(2004), Babu and Srinivasan (2012),Yadav and Panigrahi (2014), Babu and Srinivasan (2017).

5.3.6 PRICE DISCOVERY OF ALUMINIUM FUTURES AND SPOT MARKET

5.3.6.1 STATIONARITY TEST FOR ALUMINIUM FUTURE AND SPOT PRICES

The Aluminium futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{6.1}$*: The future and spot prices of Aluminium are not stationary*

<u>Table No: 5.27 Result of Stationarity test of Aluminium Spot and Future Prices</u>

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				

t-statistic	-2.577	-57.085*	-2.462	-53.375*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.679	-57.014*	-2.626	-53.448*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Aluminium Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Aluminium are found to be stationary at first difference and are integrated in the order of one.

5.3.6.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR ALUMINIUM FUTURE AND SPOT PRICES

After confirming the stationarity of Aluminium futures and spot prices, Johansen’s and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{6.2}$: There is no cointegration between future and spot prices of Aluminium

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks

H_0 r=0	545.677	535.678	25.872	19.387	Cointegrated
H_1 r=1	9.999	9.999	12.518	12.518	

Table No: 5.28 Results of Johansen's Cointegration Analysis of Aluminium Future and Spot Prices

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (545.677) and Maximum Eigen value(λ_{max}) (535.678) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (9.999) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Aluminium tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

	Δ Spot	***Δ Future***

5.3.6.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR ALUMINIUM FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Aluminium, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{6.3}$: *There is no Long run causality between Future and Spot prices of Aluminium*

$H_0^{6.4}$: *There is no Short run causality between Future and Spot prices of Aluminium*

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.480	0.000	-0.126	0.001
ΔS_{t-1}	-0.166	0.000	0.053	0.109
ΔS_{t-2}	-0.047	0.023	0.037	0.176
ΔF_{t-1}	0.317	0.000	-0.002	0.941
ΔF_{t-2}	0.129	0.000	-0.008	0.701
c	0.002	0.935	0.007	0.981
Wald Test for short run causality(Chi-square and P.Value)	105.491 (0.000)		0.172 (0.987)	

Table No: 5.29 Results of Vector Error Correction Model and Wald Test for Aluminium Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.480) and for Future equation (-0.126) of Aluminium. The spot equation reveals that about 48% of disequilibrium is corrected by spot prices everyday as compared to 13% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till 1st lag and are also influenced by futures till second lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of Aluminium, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market for Aluminium. This implies that when there is any deviation from cost of carry relationship, spot prices of Aluminium makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Aluminium. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero whereas in future equation, it was found to be insignificant. This indicates uni directional short run causality running between future and spot market of Aluminium.

. Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration Test, Vector Error Correction Model and Wald Test of Aluminium. Thus the null hypothesis is rejected and a long run and short run causality is found between Aluminium futures and spot market.

5.3.6.4 GRANGER CAUSALITY TEST FOR ALUMINIUM FUTURE AND SPOT PRICES

Granger Causality test is performed on the Aluminium Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{6.5}$: There is no lead lag relationship between Spot and Future prices of Aluminium

Table No: 5.30 Result of Granger Causality Test for Aluminium Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Aluminium Spot price does not granger cause Aluminium Future Price	5.801	0.113	Uni Directional
Aluminium Future price does not granger cause Aluminium Spot Price	483.201	0.000	

From the above table, it can be seen that probability value of null hypothesis "Aluminium spot price does not granger cause Aluminium future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Aluminium spot prices cannot be used to predict Aluminium future prices. The probability value of null hypothesis “Aluminium Future price does not granger cause Aluminium Spot price” is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Aluminium can be used to predict future Aluminium spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Aluminium during this period. This shows a clear evidence of domination of future market compared to spot market in Aluminium, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Aluminium market, future market leads and spot market follows.

The findings of the study concurs with the study of Fu and Qing (2006), Yadav and Panigrahi (2014), Saranya (2014), Babu and Srinivasan (2017) but differs from the study of Velmurugan et.al; (2015).

5.3.7 PRICE DISCOVERY OF ZINC FUTURES AND SPOT MARKET

5.3.7.1 STATIONARITY TEST FOR ZINC FUTURE AND SPOT PRICES

The Zinc futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{7.1}$: The future and spot prices of Zinc are not stationary

Table No: 5.31 Result of Stationarity test of Zinc Spot and Future Prices

	Spot		Future	
	Levels	**First**	**Levels**	**First**

		Difference		Difference
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.589	-54.821*	-1.499	-53.938*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-1.506	-54.843*	-1.475	-53.943*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Zinc Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Zinc are found to be stationary at first difference and are integrated in the order of one.

5.3.7.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR ZINC FUTURE AND SPOT PRICES

After confirming the stationarity of Zinc futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{7.2}$: *There is no cointegration between future and spot prices of Zinc*

Table No: 5.32 Results of Johansen's Cointegration Analysis of Zinc Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	418.269	415.545	25.872	19.387	Cointegrated
H_1 r=1	2.724	2.724	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of three lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (418.269) and Maximum Eigen value(λ_{max}) (415.545) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (9.999) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Zinc tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.7.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR ZINC FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Zinc, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{7.3}$: There is no Long run causality between Future and Spot prices of Zinc

$H_0^{7.4}$: There is no Short run causality between Future and Spot prices of Zinc

Table No: 5.33 Results of Vector Error Correction Model and Wald Test for Zinc Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.472) and for Future equation (-0.176) of Zinc. The spot equation reveals that about 48% of disequilibrium is corrected by spot prices everyday as compared to 18% in case of future equation. The error correction estimates shows that spot prices are affected by its lags till second lag and are also influenced by futures till third lag. The future prices are not influenced by any of its own lag and are influenced by spot prices till second lag. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of Zinc, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market for Zinc. This implies that when there is any deviation from cost of carry relationship, spot prices of Zinc makes greater adjustment to re-establish equilibrium.

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.472	0.000	-0.176	0.000
ΔS_{t-1}	-0.221	0.000	0.077	0.044
ΔS_{t-2}	-0.152	0.000	0.076	0.064
ΔS_{t-3}	-0.013	0.563	-0.025	0.432
ΔF_{t-1}	0.315	0.000	-0.046	0.246
ΔF_{t-2}	0.228	0.000	-0.039	0.248
ΔF_{t-3}	0.074	0.007	0.047	0.059
c	0.002	0.837	0.005	0.865
Wald Test for short run causality(Chi-square and P.Value)	75.565 (0.000)		10.961 (0.012)	

Wald test is performed to analyse the short run dynamics between future and spot prices of Zinc. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in both cases, coefficients are significantly different from zero indicating bi directional short run causality running between future and spot market of Zinc. Since the magnitude of chi-square is found to be higher in spot equation than future equation, , it can be inferred than even though there is bidirectional short run causality between the spot and future market, the short run causality effect is more from future to spot market for Zinc.

Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration test, Vector Error Correction Model and Wald Test of Zinc. Thus the null hypothesis is rejected and a long run and short run causality is found between Zinc futures and spot market.

5.3.7.4 GRANGER CAUSALITY TEST FOR ZINC FUTURE AND SPOT PRICES

Granger Causality test is performed on the Zinc Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{7.5}$: There is no lead lag relationship between Spot and Future prices of Zinc

Table No: 5.34 Result of Granger Causality Test for Zinc Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Zinc Spot price does not granger cause Zinc Future Price	6.199	0.003	Bi Directional
Zinc Future price does not granger cause Zinc Spot Price	336.508	0.000	

From the above table, it can be seen that probability value of null hypothesis “Zinc spot price does not granger cause Zinc future price” and “Zinc Future price does not granger cause Zinc Spot price” is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Zinc can be used to predict future Zinc spot prices and vice versa. Thus it is concluded that there is a bidirectional causal relationship from future to spot market for Zinc during this period. As the coefficient of "future prices does not granger causes spot prices" is higher in magnitude it shows a domination of future market compared to spot market in Zinc, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Zinc market, future market leads and spot market follows.

The results of the study concurs with the study of Babu and Srinivasan (2012), Sinha and Mathur (2013), Sehgal and Berlia (2013),Saranya (2014), Singh (2015),Purohit et.al; (2015),Velmurugan et.al; (2015),Gupta et.al;(2017).

5.3.8 PRICE DISCOVERY OF LEAD FUTURES AND SPOT MARKET

5.3.8.1 STATIONARITY TEST FOR LEAD FUTURE AND SPOT PRICES

The Lead futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{8.1}$*: The future and spot prices of Lead are not stationary*

<u>Table No: 5.35 Result of Stationarity test of Lead Spot and Future Prices</u>

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-2.569	-52.731*	-2.349	-50.050*

Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.610	-52.763*	-2.482	-50.070*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Lead Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Lead are found to be stationary at first difference and are integrated in the order of one.

5.3.8.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR LEAD FUTURE AND SPOT PRICES

After confirming the stationarity of Lead futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{8.2}$: There is no cointegration between future and spot prices of Lead

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks

H_0 r=0	605.224	594.589	25.872	19.387	Cointegrated
H_1 r=1	10.634	10.634	12.518	12.518	

Table No: 5.36 Results of Johansen's Cointegration Analysis of Lead Future and Spot Prices

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic (λ_{trace}) (605.224) and Maximum Eigen value(λ_{max}) (594.589) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (10.634) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Lead tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.8.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR LEAD FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Lead, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{8.3}$: *There is no Long run causality between Future and Spot prices of Lead*

$H_0^{8.4}$: *There is no Short run causality between Future and Spot prices of Lead*

Table No: 5.37 Results of Vector Error Correction Model and Wald Test for Lead Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.599) and negative and not significant for Future equation (-0.075) of Lead. The spot equation reveals that about 60% of disequilibrium is corrected by spot prices everyday as compared to 7 % in case of future equation. The error correction estimates shows that spot prices are affected by its lags till second lag and are also influenced by futures till second lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of Lead, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market for Lead. This implies that when there is any deviation from cost of carry relationship, spot prices of Lead makes greater adjustment to re-establish equilibrium.

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.599	0.000	-0.075	0.051
ΔS_{t-1}	-0.122	0.000	-0.025	0.456
ΔS_{t-2}	-0.052	0.015	-0.001	0.964
ΔF_{t-1}	0.264	0.000	0.092	0.015
ΔF_{t-2}	0.112	0.000	0.058	0.061
c	0.001	0.781	0.002	0.746
Wald Test for short run causality(Chi-square and P.Value)	63.048 (0.000)		0.729 (0.695)	

Wald test is performed to analyse the short run dynamics between future and spot prices of Lead. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in both cases, coefficients are significantly different from zero indicating bi directional short run causality running between future and spot market of Lead. Since the magnitude of chi-square is found to be higher in spot equation than future equation, , it can be inferred than even though there is bidirectional short run causality between the spot and future market, the short run causality effect is more from future to spot market for Lead.

Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration Test, Vector Error Correction Model and Wald Test of Lead. Thus the null hypothesis is rejected and a long run and short run causality is found between Lead futures and spot market.

5.3.8.4 GRANGER CAUSALITY TEST FOR LEAD FUTURE AND SPOT PRICES

Granger Causality test is performed on the Lead Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{8.5}$: There is no lead lag relationship between Spot and Future prices of Lead

Table No: 5.38 Result of Granger Causality Test for Lead Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Lead Spot price does not granger cause Lead Future Price	0.524	0.592	Uni Directional
Lead Future price does not granger cause Lead Spot Price	546.510	0.000	

From the above table, it can be seen that probability value of null hypothesis "Lead spot price does not granger cause Lead future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Lead spot prices cannot be used to predict Lead future prices. The probability value of null hypothesis "Lead Future price does not granger cause Lead Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Lead can be used to predict future Lead spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Lead during this period. This shows a clear evidence of domination of future market compared to spot market in Lead, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Lead market, future market leads and spot market follows.

The result of the study concurs with the study of Saranya (2014),Velmurugan et.al;(2015), Babu and Srinivasan (2017) but differs from the study of Figuerola and Gonzalo (2012).

5.3.9 PRICE DISCOVERY OF NICKEL FUTURES AND SPOT MARKET

5.3.9.1 STATIONARITY TEST FOR NICKEL FUTURE AND SPOT PRICES

The Nickel futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{9.1}$: The future and spot prices of Nickel are not stationary

Table No: 5.39 Result of Stationarity test of Nickel Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-2.227	-53.910*	-2.157	-52.094*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885

10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.247	-54.074*	-2.137	-52.126*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Nickel Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Nickel are found to be stationary at first difference and are integrated in the order of one.

5.3.9.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR NICKEL FUTURE AND SPOT PRICES

After confirming the stationarity of Nickel futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{9.2}$: *There is no cointegration between future and spot prices of Nickel*

Table No: 5.40 Results of Johansen's Cointegration Analysis of Nickel Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	412.469	401.044	25.872	19.387	Cointegrated
H_1 r=1	11.425	11.425	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic (λ_{trace}) (412.469) and Maximum Eigen value(λ_{max}) (401.044) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (11.425) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Nickel tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

	Δ Spot	***Δ Future***

5.3.9.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR NICKEL FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Nickel, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{9.3}$: *There is no Long run causality between Future and Spot prices of Nickel*

$H_0^{9.4}$: *There is no Short run causality between Future and Spot prices of Nickel*

Table No: 5.41 Results of Vector Error Correction Model and Wald Test for Nickel Future and Spot Prices

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.486	0.000	-0.076	0.074
ΔS_{t-1}	-0.232	0.000	-0.003	0.993
ΔS_{t-2}	-0.190	0.000	-0.041	0.245
ΔS_{t-3}	-0.077	0.008	-0.008	0.739
ΔF_{t-1}	0.334	0.000	0.046	0.280
ΔF_{t-2}	0.220	0.000	0.029	0.456
ΔF_{t-3}	0.116	0.000	0.009	0.752
c	-0.003	0.277	0.004	0.280
Wald Test for short run causality(Chi-square and P.Value)	75.277 (0.000)		2.628 (0.453)	

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.486) and negative and not significant for Future equation (-0.076) of Nickel. The spot equation reveals that about 49% of disequilibrium is corrected by spot prices everyday as compared to 8 % in case of future equation. The error correction estimates shows that spot prices are affected by its lags till third lag and are also influenced by futures till third lag. The future prices are not influenced by any of its own lag or spot prices lags. Since the coefficient of error correction term is higher in magnitude in spot equation than the future equation of Nickel, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is more from future to spot market for Nickel. This implies that when there is any deviation from cost of carry relationship, spot prices of Nickel makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Nickel. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero and for future equation, it’s not significant. This indicates there is a uni directional short run causality running between future and spot market of Nickel. So it can be inferred that there is unidirectional short run causality between the spot and future market for Nickel.

Thus a clear dominance of future market in price discovery can be seen from the results of Cointegration Test, Vector Error Correction Model and Wald Test of Nickel. Thus the null hypothesis is rejected and a long run and short run causality is found between Nickel futures and spot market.

5.3.9.4 GRANGER CAUSALITY TEST FOR NICKEL FUTURE AND SPOT PRICES

Granger Causality test is performed on the Nickel Future and spot prices to analyse the nickel lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{2.5}$: There is no nickel lag relationship between Spot and Future prices of Nickel

Table No: 5.42 Result of Granger Causality Test for Nickel Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Nickel Spot price does not granger cause Nickel Future Price	1.966	0.117	Uni Directional
Nickel Future price does not granger cause Nickel Spot Price	332.987	0.000	

From the above table, it can be seen that probability value of null hypothesis "Nickel spot price does not granger cause Nickel future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Nickel spot prices cannot be used to predict Nickel future prices. The probability value of null hypothesis "Nickel Future price does not granger cause Nickel Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Nickel can be used to predict future Nickel spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Nickel during this period. This shows a clear evidence of domination of future market compared to spot market in Nickel, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Nickel market, future market nickels and spot market follows.

The results of the study concurs with the study of Figuerola and Gonzalo (2012), Singh (2015), Saranya(2014),Velmurugan et.al; (2015), Babu and Srinivasan (2017) but differs from the study of Sinha and Mathur (2013)

5.3.10 PRICE DISCOVERY OF CARDAMOM FUTURES AND SPOT MARKET

5.3.10.1 STATIONARITY TEST FOR CARDAMOM FUTURE AND SPOT PRICES

The Cardamom futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{10.1}$*: The future and spot prices of Cardamom are not stationary*

Table No: 5.43 Result of Stationarity tests of Cardamom Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-2.072	-22.512*	-2.507	-49.774*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-2.194	-48.660*	-2.345	-49.669*
Critical Values				

1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Cardamom Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Cardamom are found to be stationary at first difference and are integrated in the order of one.

5.3.10.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR CARDAMOM FUTURE AND SPOT PRICES

After confirming the stationarity of Cardamom futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{10.2}$: There is no cointegration between future and spot prices of Cardamom

Table No: 5.44 Results of Johansen's Cointegration Analysis of Cardamom Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	105.650	100.945	25.872	19.387	Cointegrated
H_1 r=1	4.705	4.705	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (105.650) and Maximum Eigen value(λ_{max}) (100.945) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (4.705) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Cardamom tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.10.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR CARDAMOM FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Cardamom, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

	Δ Spot	***Δ Future***

The null hypotheses are framed as follows:

$H_0^{10.3}$*: There is no Long run causality between Future and Spot prices of Cardamom*

$H_0^{10.4}$*: There is no Short run causality between Future and Spot prices of Cardamom*

Table No: 5.45 Results of Vector Error Correction Model and Wald Test for Cardamom Future and Spot Prices

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.031	0.000	-0.024	0.001
ΔS_{t-1}	0.026	0.198	0.022	0.498
ΔS_{t-2}	-0.037	0.067	0.056	0.074
ΔF_{t-1}	0.136	0.000	0.075	0.000
ΔF_{t-2}	0.017	0.205	-0.021	0.330
c	0.003	0.225	0.003	0.478
Wald Test for short run causality(Chi-square and P.Value)	101.192 (0.000)		3.716 (0.156)	

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.031) and for Future equation (-0.024) of Cardamom. The spot equation reveals that about 3% of disequilibrium is corrected by spot prices everyday as compared to 2 % in case of future equation. The error correction estimates shows that spot prices are affected by its own and future prices till 1st lag. The future prices are influenced by any of its own lag till 1st lag and not influenced by any of spot lags. Since the coefficient of error correction term is marginally higher in magnitude in spot equation than the future equation of Cardamom, it can be inferred than even though there is bidirectional causality between the spot and future market, the long run causality effect is marginally more from future to spot market for Cardamom. This implies that when there is any deviation from cost of carry relationship, spot prices of Cardamom makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Cardamom. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero whereas in future equation, it was found to be insignificant. This indicates uni directional short run causality running between future and spot market of Cardamom.

Thus a marginal dominance of future market in price discovery can be seen from the results of Vector Error Correction Model and Wald Test of Cardamom. Thus the null hypothesis is rejected and a long run and short run causality is found between Cardamom futures and spot market.

5.3.10.4 GRANGER CAUSALITY TEST FOR CARDAMOM FUTURE AND SPOT PRICES

Granger Causality test is performed on the Cardamom Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{10.5}$: There is no lead lag relationship between Spot and Future prices of Cardamom

Table No: 5.46   Result of Granger Causality Test for Cardamom Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Cardamom Spot price does not granger cause Cardamom Future Price	1.946	0.055	Uni Directional
Cardamom Future price does not granger cause Cardamom Spot Price	70.190	0.000	

From the above table, it can be seen that probability value of null hypothesis "Cardamom spot price does not granger cause Cardamom future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Cardamom spot prices cannot be used to predict Cardamom future prices. The probability value of null hypothesis "Cardamom Future price does not granger cause Cardamom Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Cardamom can be used to predict future Cardamom spot prices. Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Cardamom during this period. This shows a domination of future market compared to spot market in Cardamom, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Cardamom market, future market leads and spot market follows.

The result of the study concurs with the result of the study of Nirmala et.al (2015), Natarajan and Nirupama (2015), Babu and Srinivasan (2017), Velmurugan and Amrah (2017) but differs from the study of Shivakumar (2013).

5.3.11 PRICE DISCOVERY OF MENTHA OIL FUTURES AND SPOT MARKET

5.3.11.1 STATIONARITY TEST FOR MENTHA OIL FUTURE AND SPOT PRICES

The Mentha Oil futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{11.1}$: *The future and spot prices of Mentha Oil are not stationary*

Table No: 5.47 Result of Stationarity test of Mentha Oil Spot and Future Prices

	Spot		Future	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.417	-45.106*	-1.511	-49.909*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-1.547	-46.115*	-1.695	-50.554*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Mentha Oil Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Mentha Oil are found to be stationary at first difference and are integrated in the order of one.

5.3.11.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR MENTHA OIL FUTURE AND SPOT PRICES

After confirming the stationarity of Mentha Oil futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{11.2}$: *There is no cointegration between future and spot prices of Mentha Oil*

Table No: 5.48 Results of Johansen's Cointegration Analysis of Mentha Oil Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	77.445	75.355	25.872	19.387	Cointegrated
H_1 r=1	2.091	2.091	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of five lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (77.445) and Maximum Eigen value(λ_{max}) (75.355) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (2.091) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Mentha Oil tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.11.2 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR MENTHA OIL FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Mentha Oil, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows

$H_0^{11.3}$: *There is no Long run causality between Future and Spot prices of Mentha Oil*

$H_0^{11.4}$: *There is no Short run causality between Future and Spot prices of Mentha Oil*

Table No: 5.49 Results of Vector Error Correction Model and Wald Test for Mentha Oil Future and Spot Prices

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is insignificant and negative for spot equation (-0.011) and negative and significant for Future equation (-0.040) of Mentha Oil. The spot equation reveals that about 1% of disequilibrium is corrected by spot prices everyday as compared to 4% in case of future equation. The error correction estimates shows that spot prices not influenced by its own lags and are influenced by futures till second lag. So it can be inferred that there is unidirectional causality between the spot and future market, the long run causality effect is running from spot to future market for Mentha Oil. This implies that when there is any deviation from cost of carry relationship, future prices of Mentha Oil makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot

	Δ Spot		***Δ Future***	
	Coefficient	**P.Value**	**Coefficient**	**P.Value**
ECT	-0.011	0.125	-0.040	0.000
ΔS_{t-1}	-0.022	0.403	0.091	0.008
ΔS_{t-2}	0.019	0.460	0.092	0.004
ΔF_{t-1}	0.230	0.000	0.019	0.471
ΔF_{t-2}	-0.058	0.005	-0.064	0.018
c	0.002	0.432	0.001	0.661
Wald Test for short run causality(Chi-square and P.Value)	153.933 (0.000)		13.408 (0.001)	

prices of Mentha Oil. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in both cases, coefficients are significantly different from zero indicating bi directional short run causality running between future and spot market of Mentha Oil. Since the magnitude of chi-square is found to be higher in spot equation than future equation, , it can be inferred than even though there is bidirectional short run causality between the spot and future market, the short run causality effect is more from future to spot market for Mentha Oil.

Thus in long run, spot market of mentha oil are more efficient than future market in price discovery In short run however, a dominance of future market can be seen. Thus the null hypothesis is rejected and a long run and short run causality is found between Mentha Oil futures and spot market.

5.3.11.4 GRANGER CAUSALITY TEST FOR MENTHA OIL FUTURE AND SPOT PRICES

Granger Causality test is performed on the Mentha Oil Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{11.5}$*: There is no lead lag relationship between Spot and Future prices of Mentha Oil*

Table No: 5.50 Result of Granger Causality Test for Mentha Oil Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Mentha Oil Spot price does not granger cause Mentha Oil Future Price	9.546	0.000	Bi Directional
Mentha Oil Future price does not granger cause Mentha Oil Spot Price	81.512	0.000	

From the above table, it can be seen that probability value of null hypothesis "Mentha Oil spot price does not granger cause Mentha Oil future price" and "Mentha Oil Future price does not granger cause Mentha Oil Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Mentha Oil can be used to predict future Mentha Oil spot prices and vice versa. Thus it is concluded that there is a bidirectional causal relationship from future to spot market for Mentha Oil during this period. As the coefficient of "future prices does not granger causes spot prices" is higher in magnitude it shows a domination of future market compared to spot market in Mentha Oil, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Mentha Oil market, future market leads and spot market follows.

The findings of the study are in line with the study of Athma and Rao (2013).

5.3.12 PRICE DISCOVERY OF CRUDE PALM OIL FUTURES AND SPOT MARKET

5.3.12.1 STATIONARITY TEST FOR CRUDE PALM OIL FUTURE AND SPOT PRICES

The Crude Palm Oil futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{12.1}$: *The future and spot prices of Crude Palm Oil are not stationary*

Table No: 5.51 Result of Stationarity test of Crude Palm Oil Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.838	-24.105*	-1.819	-32.360*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486

5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				
t-statistic	-1.933	-44.521*	-2.011	-48.854*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Crude Palm Oil Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices are found to be stationary at first difference and are integrated in the order of one.

5.3.12.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR CRUDE PALM OIL FUTURE AND SPOT PRICES

After confirming the stationarity of Crude Palm Oil futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{12.2}$: There is no cointegration between future and spot prices of Crude Palm Oil

Table No: 5.52 Results of Johansen's Cointegration Analysis of Crude Palm Oil Spot and Future Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks

H_0 r=0	124.419	116.127	25.872	19.387	Cointegrated
H_1 r=1	8.292	8.292	12.517	12.517	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of three lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (124.419) and Maximum Eigen value(λ_{max}) (116.127) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (8.292) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.12.3 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR CRUDE PALM OIL FUTURE AND SPOT PRICES

	Δ Spot	***Δ Future***

After confirming cointegration between spot and future prices of Crude Palm Oil, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows:

$H_0^{12.3}$: *There is no Long run causality between Future and Spot prices of Crude Palm Oil*

$H_0^{12.4}$: *There is no Short run causality between Future and Spot prices of Crude Palm Oil*

Table No: 5.53 Results of Vector Error Correction Model and Wald Test for Crude Palm Oil spot and Future prices

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.071	0.000	-0.073	0.002
ΔS_{t-1}	-0.120	0.000	0.066	0.110
ΔS_{t-2}	-0.014	0.669	0.098	0.016
ΔS_{t-3}	0.033	0.273	0.095	0.010
ΔF_{t-1}	0.266	0.000	0.011	0.765
ΔF_{t-2}	0.114	0.000	-0.005	0.889
ΔF_{t-3}	0.035	0.216	-0.029	0.388
c	0.001	0.945	0.008	0.973
Wald Test for short run causality(Chi-square and P.Value)	81.056 (0.000)		10.831 (0.012)	

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is negative and significant for both spot and future equation. The speed of adjustment towards equilibrium is found to be almost at the same rate (7%). This shows that both spot prices and future prices correct the disequilibrium by 7%. This shows that both future and spot prices are equally efficient in discovering the prices. The error correction estimates show that spot prices are influenced by its own till first lag whereas it is influenced by futures till second lag. The future prices are influenced by second and third lag of spot prices and not by any other or its own lag.

Wald test is performed to analyse the short run dynamics between future and spot prices of Crude Palm Oil. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in both cases, coefficients are significantly different from zero indicating bi directional short run causality running between future and spot market of Crude Palm Oil. Since the magnitude of chi-square is found to be higher in spot equation than future equation, , it can be inferred than even though there is bidirectional short run causality between the spot and future market, the short run causality effect is more from future to spot market for Crude Palm Oil.

Thus, it can be inferred that both spot and future market of Crude Palm Oil are equally efficient in discovering the price.

5.3.12.4 GRANGER CAUSALITY TEST FOR CRUDE PALM OIL FUTURE AND SPOT PRICES

Granger Causality test is performed on the Crude Palm Oil Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{12.5}$: There is no lead lag relationship between Spot and Future prices of Crude Palm Oil

Table No: 5.54 Result of Granger Causality Test for Crude Palm Oil Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Crude Palm Oil Spot price does not granger cause Crude Palm Oil Future Price	7.170	0.000	Bi Directional
Crude Palm Oil Future price does not granger cause Crude Palm Oil Spot Price	47.532	0.000	

From the above table, it can be seen that probability value of null hypothesis "Crude Palm Oil spot price does not granger cause Crude Palm Oil future price" and "Crude Palm Oil Future price does not granger cause Crude Palm Oil Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Crude Palm Oil can be used to predict future Crude Palm Oil spot prices and vice versa. Thus it is concluded that there is a bidirectional causal relationship from future to spot market for Crude Palm Oil during this period. As the coefficient of "future prices does not granger causes spot prices" is higher in magnitude it shows a domination of future market compared to spot market in Crude Palm Oil, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Crude Palm Oil market, future market leads and spot market follows.

The results of the study differ from the study of Velmurugan and Amrah (2017) and Ahmed (2017).

5.3.13 PRICE DISCOVERY OF COTTON FUTURES AND SPOT MARKET

5.3.13.1 STATIONARITY TEST FOR COTTON FUTURE AND SPOT PRICES

The Cotton futures and spot prices are checked for stationarity using Augmented Dickey Fuller test and Philips Perron test. The results are reported in the table below:

The null hypothesis is as follows:

$H_0^{13.1}$: *The future and spot prices of Cotton are not stationary*

Table No: 5.55 Result of Stationarity test of Cotton Spot and Future Prices

	Spot		**Future**	
	Levels	**First Difference**	**Levels**	**First Difference**
AUGMENTED DICKEY FULLER TEST				
t-statistic	-1.309	-30.914*	-1.634	-38.705*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.885	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary
PHILLIPS-PERRON TEST				

t-statistic	-1.844	-33.687*	-1.732	-38.727*
Critical Values				
1%	-3.486	-3.486	-3.486	-3.486
5%	-2.886	-2.885	-2.885	-2.885
10%	-2.579	-2.579	-2.579	-2.579
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

*MacKinnon (1996) one-sided p-values.

Before doing cointegration analysis it is important to do unit root analysis to identify the stationarity and order of integration. The above table reports the unit root analysis of log values of Cotton Spot prices and Future prices using Augmented Dickey Fuller tests and Phillips-Perron tests. The results reveal that all the series are non stationary at levels as test statistics are greater than the critical values. However by taking the first difference all the series are found to be stationary. Thus the null hypothesis is rejected and the log values of future, spot prices of Cotton are found to be stationary at first difference and are integrated in the order of one.

5.3.13.2 JOHANSEN AND JUSELIUS TEST OF COINTEGRATION FOR COTTON FUTURE AND SPOT PRICES

After confirming the stationarity of Cotton futures and spot prices, Johansen's and Juliesus cointegration test is performed and are reported in the table below:

The null hypothesis is framed as follows:

$H_0^{13.2}$: *There is no cointegration between future and spot prices of Cotton*

Table No: 5.56 Results of Johansen's Cointegration Analysis of Cotton Future and Spot Prices

Vector (r)	Trace Statistics (λ_{trace})	Maximal Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	62.715	57.998	25.872	19.387	Cointegrated
H_1 r=1	4.717	4.717	12.518	12.518	

After confirming that the futures and spot prices are stationary at first difference, Johansen's test of cointegration has been performed to analyze the long run equilibrium relationship between the variables. The optimal lag length of two lags has been identified using Schwartz information criterion. The results of Johansen's cointegration test has been reported in the table no: . Both λ_{trace} and λ_{max} statistics are used for the analysis. The results of no cointegration(r=0) is rejected as the trace statistic(λ_{trace}) (62.715) and Maximum Eigen value(λ_{max}) (57.998) is greater than the critical values 25.872 and 19.387 respectively. The alternative hypothesis of at most one co integrating equation has not been rejected as the trace statistic and maximum eigen values (4.717) are less than the critical values (12.518). Thus the null hypothesis is rejected and the presence of at most one cointegrating vector confirms that both the spot and futures markets of Cotton tend to move together in long run and any shocks which affects the equilibrium gets corrected over time.

5.3.13.2 VECTOR ERROR CORRECTION MODEL AND WALD TEST FOR

	Δ Spot	***Δ Future***

COTTON FUTURE AND SPOT PRICES

After confirming cointegration between spot and future prices of Cotton, Vector Error Correction Model is used to analyse the long run causality and Wald Test is performed to analyse the short run dynamics of the series. Results of Vector Error Correction Model and Wald Test are reported in the table below.

The null hypotheses are framed as follows:

$H_0^{13.3}$: There is no Long run causality between Future and Spot prices of Cotton

$H_0^{13.4}$: There is no Short run causality between Future and Spot prices of Cotton

Table No: 5.57 Results of Vector Error Correction Model and Wald Test for Cotton Future and Spot Prices

	Coefficient	P.Value	Coefficient	P.Value
ECT	-0.042	0.000	0.001	0.880
ΔS_{t-1}	0.004	0.892	-0.013	0.768
ΔS_{t-2}	0.017	0.506	0.059	0.142
ΔF_{t-1}	0.242	0.000	0.009	0.761
ΔF_{t-2}	0.078	0.000	0.004	0.893
c	0.007	0.790	0.008	0.776
Wald Test for short run causality(Chi-square and P.Value)	165.715 (0.000)		2.185 (0.335)	

After identifying single cointegrating vector, VECM is applied by incorporating Error correction term to provide insight to the adjustment process in case of disequilibrium. For the existence of long run relationship it is required that the error correction term should be negative and significant. From the above table it can be seen that the coefficients of error correction term is significant and negative for spot equation (-0.042) and not significant and negative for Future equation (-0.001) of Cotton. The spot equation reveals that about 4% of disequilibrium is corrected by spot prices everyday as compared to 0.1% in case of future equation. The error correction estimates shows that spot prices are not affected by its own lags and are affected by future prices till second lag. The future prices are not influenced by any of its own lag or spot lags. Thus it can be inferred that there is unidirectional long run causality between the spot and future market, the long run causality effect is from future to spot market for Cotton. This implies that prices are first discovered in future market and when there is any deviation from cost of carry relationship, spot prices of Cotton makes greater adjustment to re-establish equilibrium.

Wald test is performed to analyse the short run dynamics between future and spot prices of Cotton. The cross terms in spot and future equations are checked whether they are simultaneously zero at 5% significance level. The results show that in spot equation, coefficients are significantly different from zero whereas in future equation, it was found to be insignificant. This indicates uni directional short run causality running between future and spot market of Cotton.

Thus a marginal dominance of future market in price discovery can be seen from the results of Vector Error Correction Model and Wald Test of Cotton. Thus the null hypothesis is rejected and a long run and short run causality is found between Cotton futures and spot market.

5.3.13.4 GRANGER CAUSALITY TEST FOR COTTON FUTURE AND SPOT PRICES

Granger Causality test is performed on the Cotton Future and spot prices to analyse the lead lag relationship between the series. The results of granger causality test are reported in the table below:

The null hypothesis has been framed as follows:

$H_0^{13.5}$: There is no lead lag relationship between Spot and Future prices of Cotton

Table No: 5.58 Result of Granger Causality Test for Cotton Future and Spot Prices

Null Hypothesis	F Statistic	P.Value	Direction
Cotton Spot price does not granger cause Cotton Future Price	1.119	0.327	Uni Directional
Cotton Future price does not granger cause Cotton Spot Price	118.758	0.000	

From the above table, it can be seen that probability value of null hypothesis "Cotton spot price does not granger cause Cotton future price" is more than the 5% significance level, hence we cannot the reject the null hypothesis and it can be inferred that past values of Cotton spot prices cannot be used to predict Cotton future prices. The probability value of null hypothesis "Cotton Future price does not granger cause Cotton Spot price" is less than 0.05, hence we reject the null hypothesis and it can be inferred that past values of future prices of Cotton can be used to predict future Cotton spot prices.

Thus it is concluded that there is a unidirectional causal relationship from future to spot market for Cotton during this period. This shows a clear evidence of domination of future market compared to spot market in Cotton, where the information or shock is first reflected in future market which is then reflected in spot market. Thus in Cotton market, future market leads and spot market follows.

The results of the study concur with the study of Kumar et.al; (2017) but differ from the study of Easwaran (2009), Prava (2017).

5.4 TO ANALYSE THE VOLATILITY SPILLOVER BETWEEN FUTURE AND SPOT PRICES OF SELECTED COMMODITIES

To analyse the volatility spillover bivariate EGARCH (1, 1) is employed to know how news from one market affects the volatility in another market. Before estimating EGARCH model, it is necessary to analyse the heteroscedastic nature of the series. The heteroscedaticity tests such as ARCH LM test is used to prove the heteroscedasticity or ARCH effect in the time series. The presence of ARCH effect confirms that the use of ARCH/GARCH family models is the appropriate model for measuring the volatility. The results of ARCH LM Test for the selected commodities are presented in the table below:

Table No: 5.59 Results of ARCH LM Test for the Selected Commodities

H_0: There are no ARCH effects

Sl.No	Name of the Commodity	F-Statistic	P.Value

I	**BULLION**			
1.	Gold	*Futures*	38.886	0.000
		Spot	90.482	0.000
2.	Silver	*Futures*	79.783	0.000
		Spot	90.780	0.000
II	**BASE METALS**			
1.	Copper	*Futures*	135.757	0.000
		Spot	73.490	0.000
2.	Aluminium	*Futures*	112.021	0.000
		Spot	308.476	0.000
3.	Zinc	*Futures*	34.468	0.000
		Spot	49.816	0.000
4.	Lead	*Futures*	23.243	0.000
		Spot	16.427	0.001
5.	Nickel	*Futures*	227.569	0.000
		Spot	17.927	0.000
Table 5.59 (Continued)				
III	**ENERGY**			
1.	Crude Oil	*Futures*	90.596	0.000
		Spot	90.596	0.000
2.	Natural Gas	*Futures*	36.932	0.048
		Spot	45.651	0.031
IV	**AGRICULTURAL COMMODITIES**			
1.	Cardamom	*Futures*	98.67	0.000
		Spot	99.009	0.000
2.	Mentha Oil	*Futures*	25.989	0.000
		Spot	157.165	0.000
3.	Cotton	*Futures*	6.843	0.000
		Spot	16.168	0.001
4.	Crude Palm Oil	*Futures*	22.667	0.000
		Spot	21.345	0.000

The result of heterocedasticity tests reveals the presence of ARCH effect in all the selected commodities. It is found to be significant at 5% level. This confirms that for measuring volatility, ARCH/GARCH family models are appropriate. Hence for measuring the volatility spillover, Exponential Generalised Auto Regressive Conditional Heteroscedasticity (EGARCH) model have been used which has been found to be superior than other models of GARCH, due to the fact that it captures the asymmetric relationship between the returns and volatility (Kumar and Shollapur, 2015). Tse(1999) used two stage approach for estimating the model. At first VECM model is applied and the residuals from these equations are extracted. The squared lagged residuals are then used in the bivariate EGARCH model. The same method is used in this study to analyse the volatility spillover between future and spot markets of commodities. The coefficient Ψ_f and Ψ_s reveals the volatility spillover between the markets. The coefficient Υ_f and Υ_s reveals the asymmetric volatility effect or the leverage effect, which measures whether bad news creates more volatility than good news. The coefficients need to be negative and significant to confirm the presence of leverage effect. Volatility persistence is captured by the absolute values of β_f and β_s. The larger the value, the longer the time taken by the volatility to die out. The results of the volatility spillover using Bivariate EGARCH (1, 1) model for the selected commodities spot and futures market are presented below.

5.4.1 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF GOLD

The volatility spillover using Bi variate EGARCH (1, 1) model for Gold spot and futures are shown in the table below:

Table No: 5.60 Results of Bivariate EGARCH (1, 1) Model for Gold

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.428	0.023	-18.072	0.000	ω_f	-0.125	0.007	-16.792	0.000
α_s	0.212	0.024	8.747	0.000	α_f	0.139	0.011	13.743	0.000
β_s	0.667	0.017	37.110	0.000	β_f	0.945	0.004	213.725	0.000

Υ_s	0.020	0.014	1.494	0.136	Υ_f	0.0305	0.006	4.830	0.000
Ψ_f	0.076	0.004	19.332	0.000	Ψ_s	0.017	0.002	8.947	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		1.698		ARCH-LM	F Statistic		0.035	
	P Value		0.192			P Value		0.852	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of gold. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in gold market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the gold spot and futures market. From the analysis it can be concluded that there is no leverage effect in the gold market. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.945) is more than the value of β_s(0.667). So, it can be inferred that the volatility persistence is very high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concurs with the study of Shihabudheen and Padhi (2010), Gupta and Ravi (2013), Behera (2015) but differs from the study of Srinivasan and Ibrahim(2012) and Thenmozhi and Priya (2008).

5.4.2 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF SILVER

The volatility spillover using Bi variate EGARCH (1, 1) model for Silver spot and futures are shown in the table below:

Table No: 5.61 Results of Bivariate EGARCH (1, 1) Model for Silver

Coefficients	**Dependent Variable**	Coefficients	**Dependent Variable**

	Spot					Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	0.009	0.017	0.521	0.603	ω_f	-0.062	0.011	-5.981	0.000
α_s	0.125	0.020	6.356	0.000	α_f	0.198	0.014	13.412	0.000
β_s	0.602	0.023	26.621	0.000	β_f	0.889	0.010	92.443	0.000
Υ_s	0.009	0.014	0.645	0.519	Υ_f	0.022	0.009	2.463	0.014
Ψ_f	279.18	13.810	20.215	0.000	Ψ_s	70.719	6.575	10.757	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		0.294		ARCH-LM	F Statistic		0.508	
	P Value		0.587			P Value		0.476	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Silver. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in gold market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the gold spot and futures market. From the analysis it can be concluded that there is no leverage effect in the Silver market. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.889) is more than the value of β_s(0.602). So, it can be inferred that the volatility persistence is very high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concur with the study of Thenmozhi and Priya (2008), Shihabudheen and Padhi (2010) and Behera(2015).

5.4.3 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF CRUDE OIL

The volatility spillover using Bi variate EGARCH (1, 1) model for Silver spot and futures are shown in the table below:

Table No: 5.62 Results of Bi variate EGARCH (1, 1) Model for Crude Oil

Coefficients	**Dependent Variable Spot**				Coefficients	**Dependent Variable Futures**			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	0.051	0.014	3.655	0.000	ω_f	-0.059	0.008	-7.385	0.000
α_s	0.117	0.017	6.577	0.000	α_f	0.125	0.012	10.048	0.000
β_s	0.818	0.009	89.240	0.000	β_f	0.970	0.003	315.629	0.000
Υ_s	-0.110	0.015	-7.305	0.000	Υ_f	-0.074	0.009	-8.224	0.000
Ψ_f	118.02	6.565	17.977	0.000	Ψ_s	20.753	2.662	7.796	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	0.336			ARCH-LM	F Statistic	1.673		
	P Value	0.562				P Value	0.196		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Crude oil. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Crude oil market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the crude oil spot and futures market. From the analysis it can be concluded that there is leverage effect in the crude oil futures and spot market. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur(2015) leverage effect is estimated to be 1.24 and 1.16 for spot and futures market of crude oil. This implies that a negative shock would increase the volatility by 1.24 and 1.19 times than positive shock of same magnitude for crude oil spot and futures market of crude oil respectively. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.97) is more than the value of β_s (0.818). So, it can be inferred that the volatility persistence is very high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concur with the study of Shihabudheen and Padhi (2010), Gupta and Ravi (2013), Sehgal et.al;(2013) and Behera(2015) but differs with the study of Thenmozhi and Priya (2008).

5.4.4 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF NATURAL GAS

The volatility spillover using Bi variate EGARCH (1, 1) model for Natural Gas spot and futures are shown in the table below:

Table No: 5.63 Results of Bi variate EGARCH (1, 1) Model for Natural Gas

Coefficients	**Dependent Variable Spot**				Coefficients	**Dependent Variable Futures**			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	0.809	0.059	13.719	0.000	ω_f	-0.129	0.012	-11.595	0.000
α_s	-0.010	0.017	-0.616	0.538	α_f	0.106	0.012	9.005	0.000
β_s	0.448	0.032	13.808	0.000	β_f	0.970	0.004	270.986	0.000
Υ_s	0.060	0.018	3.345	0.000	Υ_f	-0.038	0.006	-5.845	0.000
Ψ_f	164.84	8.950	18.417	0.000	Ψ_s	15.440	1.743	8.856	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	0.262			ARCH-LM	F Statistic	0.346		
	P Value	0.609				P Value	0.556		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Natural Gas. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Natural Gas. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the natural gas spot and futures market. From the analysis it can be concluded that there is leverage effect in the natural gas futures market. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur (2015) leverage effect is estimated to be 1.08 which implies that a negative shock would increase volatility by 1.08 times more than the positive shock in futures market of Natural gas. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.97) is more than the value of β_s (0.448). So, it can be inferred that the volatility persistence is very high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concurs with the study of Behera(2015) but differs from the study of Sehgal et.al;(2013).

5.4.5 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF COPPER

The volatility spillover using Bi variate EGARCH (1, 1) model for Copper spot and futures are shown in the table below:

Table No: 5.64 Results of Bi variate EGARCH (1, 1) Model for Copper

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value

ω_s	0.084	0.019	4.338	0.000	ω_f	-0.078	0.006	-13.009	0.000
α_s	0.033	0.018	1.870	0.062	α_f	0.116	0.009	13.434	0.000
β_s	0.497	0.019	25.719	0.000	β_f	0.982	0.002	421.711	0.000
Υ_s	0.011	0.015	0.782	0.000	Υ_f	-0.045	0.005	-9.284	0.000
Ψ_f	619.44	24.910	24.866	0.000	Ψ_s	22.445	4.354	5.154	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		3.345		ARCH-LM	F Statistic		2.376	
	P Value		0.254			P Value		0.123	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Copper. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Copper. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the copper spot and futures market. From the analysis it can be concluded that there is leverage effect in the natural gas futures market. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur (2015) leverage effect is estimated to be 1.09 which implies that a negative shock would increase volatility by 1.09 times more than the positive shock in futures market of Copper. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.982) is more than the value of β_s (0.497). So, it can be inferred that the volatility persistence is very high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concurs with the study of Sehgal et.al; (2013) Behera(2015).

5.4.6 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF ALUMINIUM

The volatility spillover using Bi variate EGARCH (1, 1) model for Aluminium spot and futures are shown in the table below:

Table No: 5.65 Results of Bivariate EGARCH (1, 1) Model For Aluminium

Coefficients	**Dependent Variable Spot**				Coefficients	**Dependent Variable Futures**			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.075	0.008	-9.114	0.000	ω_f	-0.066	0.008	-7.722	0.000
α_s	0.092	0.009	9.878	0.000	α_f	0.083	0.011	7.318	0.000
β_s	0.889	0.010	87.024	0.000	β_f	0.953	0.006	157.402	0.000
Υ_s	0.037	0.007	5.273	0.000	Υ_f	0.012	0.007	1.644	0.102
Ψ_f	215.29	16.036	13.425	0.000	Ψ_s	72.593	11.372	6.383	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	2.445			ARCH-LM	F Statistic	2.591		
	P Value	0.535				P Value	0.751		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Aluminium. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Aluminium market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the Aluminium spot and futures market. From the analysis it can be concluded that there is no leverage effect in the Aluminium market. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.953) is more than the value of β_s(0.889). So, it can be inferred that the volatility persistence is high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study are in line with the findings of Fu and Qing (2006).

5.4.7 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF ZINC

The volatility spillover using Bi variate EGARCH (1, 1) model for Zinc spot and futures are shown in the table below:

Table No: 5.66 Results of Bi variate EGARCH (1, 1) Model for Zinc

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.044	0.008	-4.995	0.000	ω_f	-0.071	0.008	-8.641	0.000
α_s	0.070	0.012	5.856	0.000	α_f	0.100	0.011	9.176	0.000
β_s	0.972	0.004	256.233	0.000	β_f	0.978	0.003	305.584	0.000
Υ_s	-0.007	0.006	-1.164	0.244	Υ_f	-0.0007	0.006	-0.121	0.904
Ψ_f	34.902	4.903	7.118	0.000	Ψ_s	33.584	4.774	7.034	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	1.669			ARCH-LM	F Statistic	0.023		
	P Value	0.197				P Value	0.879		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Zinc. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Zinc market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals that there is no leverage effect in the Zinc spot and futures market. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.978) is more than the value of β_s (0.972). So, it can be inferred that the volatility persistence is very high in futures market and spot market. Thus, the impact of new information on the volatility in futures market and spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concurs with the study of Sehgal et.al; (2013)

5.4.8VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF LEAD

The volatility spillover using Bi variate EGARCH (1, 1) model for Lead spot and futures are shown in the table below:

Table No: 5.67 Results of Bivariate EGARCH(1, 1) Model For Lead

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.044	0.007	-6.611	0.000	ω_f	-0.069	0.007	-9.150	0.000
α_s	0.067	0.009	7.279	0.000	α_f	0.108	0.010	10.857	0.000
β_s	0.985	0.002	473.172	0.000	β_f	0.978	0.003	284.997	0.000
Υ_s	0.003	0.005	0.591	0.554	Υ_f	-0.006	0.006	-1.105	0.269
Ψ_f	19.608	3.173	6.179	0.000	Ψ_s	15.509	1.927	8.047	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	0.0009			ARCH-LM	F Statistic	0.471		
	P Value	0.975				P Value	0.493		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Lead. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Lead market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the Lead spot and futures market. From the analysis it can be concluded that there is no leverage effect in the Lead market. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.978) and β_s(0.985). So, it can be inferred that the volatility persistence is high in futures market and spot market. Thus, the impact of new information on the volatility in futures and spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concurs with the study of Sehgal et.al; (2013)

5.4.9 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF NICKEL

The volatility spillover using Bi variate EGARCH (1, 1) model for Nickel spot and futures are shown in the table below:

Table No: 5.68 Results of Bivariate EGARCH (1, 1) Model For Nickel

Coefficients	**Dependent Variable Spot**				Coefficients	**Dependent Variable Futures**			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.054	0.008	-6.887	0.000	ω_f	-0.073	0.009	-8.204	0.000
α_s	0.101	0.009	10.211	0.000	α_f	0.134	0.012	11.384	0.000
β_s	0.974	0.003	315.260	0.000	β_f	0.971	0.004	230.115	0.000

Υ_s	0.005	0.005	0.873	0.386	Υ_f	-0.014	0.007	-2.093	0.036
Ψ_f	19.084	2.031	9.397	0.000	Ψ_s	12.805	2.373	5.394	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		0.274		ARCH-LM	F Statistic		3.079	
	P Value		0.600			P Value		0.079	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Nickel. The findings are consistent with the price discovery results. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Nickel. The coefficients Υ_s and Υ_f reveals the leverage effect in the Nickel spot and futures market. From the analysis it can be concluded that there is leverage effect in the Nickel futures market. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur (2015) leverage effect is estimated to be 1.03 which implies that a negative shock would increase volatility by 1.03 times more than the positive shock in futures market of Nickel. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.971) and β_s (0.974) is quite high. So, it can be inferred that the volatility persistence is very high in futures market and spot market. Thus, the impact of new information on the volatility in futures and spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

5.4.10 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF CARDAMOM

The volatility spillover using Bi variate EGARCH (1, 1) model for Cardamom spot and futures are shown in the table below:

Table No: 5.69 Results of Bi variate EGARCH (1, 1) Model for Cardamom

Coeff icient	**Dependent Variable**	Coeff icient	**Dependent Variable**

	Spot					Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.146	0.005	-26.800	0.000	ω_f	0.0540	0.006	8.532	0.000
α_s	0.222	0.007	31.584	0.000	α_f	0.087	0.008	10.351	0.000
β_s	0.964	0.001	714.346	0.000	β_f	0.925	0.005	184.203	0.000
Υ_s	-0.012	0.004	-2.737	0.006	Υ_f	-0.007	0.007	-0.994	0.320
Ψ_f	15.633	1.399	11.169	0.000	Ψ_s	31.004	2.228	13.916	0.000
Residual Diagnostics									
ARCH-LM	F Statistic	0.738			ARCH-LM	F Statistic	0.843		
	P Value	0.394				P Value	0.358		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Cardamom. . From the magnitude of coefficient, it can be concluded that volatility spillover from Spot to future are stronger in cardamom market. This shows that even though price is discovered in future market in cardamom, the same is not used by farmers as the reference price. This may be due to the lack of technology and uncertainty surrounding the participation in futures market. The coefficients Υ_s and Υ_f reveals the leverage effect in the Cardamom spot and futures market. From the table above it can be seen that there is leverage effect in spot market of Cardamom. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur (2015) leverage effect is estimated to be 1.02 which implies that a negative shock would increase volatility by 1.02 times more than the positive shock in spot market of Cardamom. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. . In the above table the value of β_s (0.964) is more than the value of β_f (0.925). So it can be inferred that the volatility persistence is high in spot market and the impact of new information on the volatility in spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified

The findings of the study concur with the study of Mahalik et.al; (2009) and Velmurgan and Amrah (2017).

5.4.11 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF MENTHA OIL

The volatility spillover using Bi variate EGARCH (1, 1) model for Mentha Oil spot and futures are shown in the table below:

Table No: 5.70 Results of Bi variate EGARCH (1, 1) Model For Mentha Oil

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.152	0.008	-19.210	0.000	ω_f	-0.057	0.013	-4.381	0.000
α_s	0.210	0.011	18.829	0.000	α_f	0.168	0.014	11.718	0.000
β_s	0.939	0.004	220.934	0.000	β_f	0.915	0.008	108.734	0.000
Υ_s	0.041	0.006	7.202	0.000	Υ_f	0.071	0.008	8.354	0.000
Ψ_f	47.731	5.981	7.980	0.000	Ψ_s	54.945	10.635	5.166	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		0.085		ARCH-LM	F Statistic		0.088	
	P Value		0.771			P Value		0.767	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Mentha Oil. From the magnitude of coefficient, it can be concluded that volatility spillover from Spot to future are stronger in Mentha oil market. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the Mentha Oil spot and futures market. From the table above it can be seen that there is no leverage effect in future and spot market of Mentha Oil. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. . In the above table the value of β_s (0.939) is more than the value of β_f (0.915). So it can be inferred that the volatility persistence is high in spot market and the impact of new information on the volatility in spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concur with the study of Malhotra and Sharma (2016), Sehgal et.al; (2014), Chhajjed and Mehta (2015) and Athma and Rao (2013).

5.4.12 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF CRUDE PALM OIL

The volatility spillover using Bi variate EGARCH (1, 1) model for Crude Palm Oil spot and futures are shown in the table below:

Table No: 5.71 Results of Bi variate EGARCH (1, 1) Model for Crude Palm Oil

Coefficients	**Dependent Variable Spot**				Coefficients	**Dependent Variable Futures**			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.241	0.012	-19.279	0.000	ω_f	-0.117	0.011	-11.557	0.000
α_s	0.263	0.014	18.576	0.000	α_f	0.157	0.015	10.389	0.000
β_s	0.854	0.012	70.632	0.000	β_f	0.928	0.006	146.691	0.000

Υ_s	-0.005	0.007	-0.658	0.511	Υ_f	-0.036	0.008	-4.810	0.000
Ψ_f	115.84	8.457	13.696	0.000	Ψ_s	91.963	3.143	29.262	0.000
Residual Diagnostics									
ARCH-LM	F Statistic		0.364		ARCH-LM	F Statistic		1.119	
	P Value		0.546			P Value		0.290	

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Crude Palm Oil. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Crude Palm Oil. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the Crude Palm Oil spot and futures market. From the analysis it can be concluded that there is leverage effect in the Crude Palm Oil futures market. As explained by Koutmos and Tucker (1996) and Kumar and Shollapur (2015) leverage effect is estimated to be 1.07 which implies that a negative shock would increase volatility by 1.07 times more than the positive shock in futures market of Crude Palm Oil. Volatility persistence is measured by the coefficients β_s and β_f. The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.928) is more than the value of β_s(0.854). So, it can be inferred that the volatility persistence is high in futures market compared to spot market. Thus, the impact of new information on the volatility in futures market takes longer time to die out than in spot market. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study concur with the study of Malhotra and Sharma (2016), Chhajjed and Mehta (2015) Velmurugan and Amrah (2017)

5.4.13 VOLATILITY SPILLOVER BETWEEN SPOT AND FUTURE PRICES OF COTTON

The volatility spillover using Bi variate EGARCH (1, 1) model for Cotton spot and futures are shown in the table below:

Table No: 5.72 Results of Bi variate EGARCH (1, 1) Model For Cotton

Coefficients	Dependent Variable Spot				Coefficients	Dependent Variable Futures			
	Value	S.E	Z Statistic	P Value		Value	S.E	Z Statistic	P Value
ω_s	-0.155	0.009	-16.854	0.000	ω_f	-0.067	0.007	-9.467	0.000
α_s	0.139	0.012	11.666	0.000	α_f	0.080	0.012	6.654	0.000
β_s	0.963	0.002	379.648	0.000	β_f	0.966	0.009	109.770	0.000
Υ_s	0.028	0.005	5.567	0.000	Υ_f	0.006	0.007	0.864	0.387
Ψ_f	147.13	14.459	10.175	0.000	Ψ_s	104.81	41.705	2.513	0.012
Residual Diagnostics									
ARCH-LM	F Statistic	0.115			ARCH-LM	F Statistic	0.220		
	P Value	0.735				P Value	0.639		

The important estimates from the above table are Ψ_f and Ψ_s which measures the volatility spillover between future and spot markets. From the above table it can be seen that there is a bidirectional volatility spillover between spot and futures of Cotton. From the magnitude of coefficient, it can be concluded that volatility spillover from future to spot market are stronger in Cotton. The findings are consistent with the price discovery results. The coefficients Υ_s and Υ_f reveals the leverage effect in the Cotton spot and futures market. From the analysis it can be concluded that there is no leverage effect in the Cotton Spot and future markets. Volatility persistence is measured by the coefficients β_s and $\beta_{f.}$ The absolute value of the coefficients reveals the persistence of volatility. In the above table the value of β_f (0.966) and β_s(0.963) are quite high. So, it can be inferred that the volatility persistence is high in futures and spot market of cotton. Thus, the impact of new information on the volatility in futures and spot market takes longer time to die out. The diagnostic checking on the squared residuals for heteroscedasticity is done by using ARCH LM test. The insignificant coefficients reveal that the residual does not exhibit arch effect and the model is well specified.

The findings of the study are in line with the findings of Brahmaiah and Srinivasan (2016).