AN EMPIRICAL STUDY ON COMMODITY DERIVATIVES AND ITS IMPACT ON EQUITY MARKET IN INDIA

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MAY 2017

DECLARATION

I, Mr. Brahma Edwin Barreto, hereby declare that the work reported in this thesis entitled "An Empirical Study On Commodity Derivatives And Its Impact On Equity Market In India" submitted to the Goa University, Taleigao-Goa in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Commerce is an authentic record of my work carried out under the supervision of Dr. B. Ramesh, Professor, Department of Commerce, Goa University, Goa.

This work has not previously formed the basis for the award of any degree, diploma or certificate of this or other University. The references made to the previous works of other authors have been clearly indicated and duly acknowledged in the list of references.

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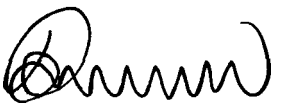
CERTIFICATE

This is to certify that the work reported in the PhD. thesis entitled "An Empirical Study On Commodity Derivatives And Its Impact On Equity Market In India" submitted by Mr. Brahma Edwin Barreto to the Goa University, Goa for the degree of Doctor of Philosophy in Commerce is a bonafide record of his original work carried out by him under my supervision and guidance.

This work has not been submitted elsewhere in part or in full to any university or institution of learning for the award of any degree or diploma.



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DEDICATED TO

My parents

Late Shri. John Rosario Barreto

and

Smt. Maria Jesuina Barreto

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Brahma Edwin Barreto

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LIST OF ABBREVIATIONS

Sr. No	Abbreviations	Full Form
1.	ACE	Ace Derivatives and Commodity Exchange Ltd
2.	ADF	Augmented Dickey Fuller
3.	AIC	Akaike Information Criterion
4.	ARCH	Autoregressive Conditional Hetroskedasticity
5.	ATF	Aviation Turbine Fuel
6.	BCI	Bache Commodity Index
7.	BSE	Bombay Stock Exchange
8.	CBOT	Chicago Board of Trade
9.	CEO	Chief Executive Officer
10.	CNX	Credit Rating Information Services of India Limited and National Stock Exchange of India
11.	CRB	Commodity Research Bureau
12.	CRISIL	Credit Rating Information Service of India Limited
13.	CTT	Commodities Transaction Tax
14.	CWC	Central Warehousing Corporation
15.	DCC	Dynamic Conditional Correlation
16.	DEPA	Department of Economic Policy and Analysis
17.	DJAIG	Dow Jones AIG Commodity Index
18.	DOLS	Dynamic Ordinary Least Squares
19.	DWBIS	Data Warehousing and Business Intelligence System
20.	ECT	Error Correction Term
21.	EFD	Enforcement Department
22.	EGARCH	Exponential Generalized Autoregressive Conditional Hetroskedasticity
23.	FCRA	Forward Contracts Regulation Act
24.	FMC	Forwards Market Commission
25.	FMOLS	Fully Modified Ordinary Least Squares
26.	FPE	Final Prediction Error
27.	GAICL	Gujarat Agro-Industries Corporation Ltd
28.	GARCH	Generalized Autoregressive Conditional Hetroskedasticity

29.	GARCH M	GARCH in the Mean
30.	GED	Generalised Error Distribution
31.	GFTC	Commodity Futures Trading Commission
32.	GSAMB	Gujarat State Agricultural Marketing Board
33.	GST	Goods and Service Tax
34.	HAFED	Haryana State Cooperative Supply & Marketing Federation Ltd
35.	HDPE	High Density Polyethylene
36.	HQ	Hannan-Quinn Information Criterion
37.	IAB	International Advisory Board
38.	ICEX	India Commodity Exchange Ltd
39.	ICICI	Industrial Credit and Investment Corporation
40.	IDFC	Infrastructure Development Finance Company
41.	IFFCO	Indian Farmers Fertilizer Cooperative Ltd
42.	IFFCO	Indian Farmers Fertilizer Cooperative Limited
43.	IFSC	International Financial Services Centres
44.	IMSS	Integrated market Surveillance System
45.	ISD	Integrated Surveillance Department
46.	IVD	Investigations Department
47.	KPSS	Kwiatkowki Phillips Schmidt Shin
48.	KSE	Karachi Stock Exchange
49.	LAD	Legal Affairs Department
50.	LAGRIFP	Lagged Agricultural Future Price
51.	LCOMDEXFP	Lagged Comdex Future Price
52.	LENERGYFP	Lagged Energy Future Price
53.	LIC	Life Insurance Corporation of India
54.	LME	London Metal Exchange
55.	LOGL	Log Likelihood
56.	MCX	Multi Commodity Exchange of India Ltd
57.	MCXAGRI	MCX Agriculture
58.	MIRSD	Market Intermediaries Regulation & Supervision Department
59.	MMTC	Metals and Minerals Trading Corporation of India

60.	NABARD	National Bank of Agriculture and Rural Development
61.	NAFED	National Agricultural Cooperative Marketing Federation of India
62.	NAFED	National Agricultural Cooperative Marketing Federation of India
63.	NBOT	National Board of Trade
64.	NCDEX	National Commodity Derivatives Exchange Ltd.
65.	NIAM	National Institution of Agricultural Marketing
66.	NMCE	National Multi Commodity Exchange Ltd
67.	NOL	Neptune Overseas Ltd
68.	NSE	National Stock Exchange of India
69.	NSEL	National Spot Exchange Limited
70.	NYMEX	New York Mercantile Exchange
71.	PNB	Punjab National Bank
72.	PP	Phillips Perron
73.	PP	Polypropylene
74.	PPP	Public Private Partnership
75.	PVC	Poly Vinyl Chloride
76.	REC	Rural Electrification Corporation Ltd
77.	S & P	Standard and Poor's
78.	S & P GSCI	Goldman Sachs Commodity Index
79.	SC	Schwarz Information Criterion
80.	SCRA	Securities Contracts Regulation Act
81.	SEBI	Securities and Exchange Board of India
82.	UCX	Universal Commodity Exchange Ltd
83.	USA	United States of America
84.	VAR	Vector Auto Regression
85.	VAT	Value Added Tax
86.	VECM	Vector Error Correction Model

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CHAPTER I

INTRODUCTION

1.1 Preface

India is a commodity dependent economy wherein more than two thirds of the populace are dependent on agriculture and agricultural commodities for their livelihood. Most surprisingly the Indian commodity markets are under developed; however, in recent years investing in commodities has undergone a sea change and has witnessed sturdy growth with many innovations.

The concept of trading in commodities is not new to India, as trading in commodities was very much in existence even during ancient times. It is well documented as one the most efficient forms of markets until the early 1970s. However, due to the numerous restrictions on trading, growth of commodity markets remained underdeveloped. Recently several of these crippling restrictions have been done away with, and this has led to novel developments and vibrant growth of the Indian commodity markets.

In India, the commodity derivatives market plays a pivotal role in futures trading, risk sharing and information pooling, thereby, drawing extensive attention towards itself. The trading in commodity derivatives accomplishes two key functions, in particular, price risk management and price discovery, with reference to any given commodity. The commodity derivatives market offers an effective mechanism for price risk management that covers all stakeholders who are participants in the commodity trading process. The stakeholders range from the producers, traders and processors up to the exporters and importers and the consumers of a commodity. The commodity derivatives market presents trading, hedging and arbitrage opportunities to the market players. It is also useful to all sectors of the economy, as it assures stability in supply and demand positions and also eliminates the perils of price uncertainty, promotes competition and plays the role of a price guide, to the farmer and other stakeholders in the economy.

Commodities play a noteworthy role in the economic development of our country. After liberalization of the Indian economy in the year 1991, a series of measures were taken to open-up the commodity derivatives market. A very noteworthy step being the setting up of multi commodity exchanges at the national level, as per the proposal made by the then market regulator, the Forwards Market Commission (FMC).

1.2 Commodity:

A commodity is any type of a product which has a value, which in turn can be produced, purchased, disposed and consumed. They represent the products related to the primary section of the economy. The primary section of the economy is primarily related to mining of raw materials and agriculture which provide the main raw materials for the secondary section of the economy.

Commodities are broadly classified as follows:

1. **Bullion:** Platinum, Gold and Silver
2. **Metals:** Iron Nickel, Copper, Aluminum, Lead, Tin, Zinc and Steel
3. **Cereals & Pulses:** Wheat, Maize, Gram and Barley
4. **Soft Commodities**: Cocoa, Sugar, Gur and Coffee
5. **Live-Stock:** Live Cattle and Pork Bellies
6. **Oil & Oil seeds:** Soya Oil, Palm Oil, Kapasia Khalli and Soyabean
7. **Fiber:** Cotton, Kapas
8. **Spices:** Cardmum, Coriander, Pepper Turmeric, Cummin seeds and Chillies
9. **Energy:** Crude Oil, Gasoline, Natural Gas, Coal, Electricity and ATF
10. **Weather:** Carbon
11. **Others:** Almonds, Potato, Gaur Seeds, Mentha Oil and Menthol flakes

1.3 Market:

A market is a particular place wherein sellers and buyers come together to exchange services and goods for a amount which is normally in terms of money. The tremendous development in the field of information technology has facilitated the present day sellers and buyers from various areas to do transactions in the electronic marketplace. The present day trading and settlement of transactions in electronic form has led to a revolution in the commodity markets. Therefore, the market place in the physical form is presently irrelevant for the purpose of transfer of services and goods in return for consideration.

1.4 Commodity Market:

The commodity market is a market place wherein primary or raw products and commodities are traded. Historically, the sellers used to get their items to a market which were kept in the market and interested buyers used to visit these market places and inspect the items and then there were negotiations between the seller and the buyer in terms of quality, price and quantity. A mutual deal would then be arrived on the quality, quantity and prices to be sold and purchased. These commodities are now traded on the regulated commodity exchanges. Commodity markets are akin to equity markets, however, here commodities are bought or sold instead of shares.

1.5 Commodity Derivatives:

A commodity derivative may be defined as a monetary instrument that is tradable on or off a designated exchange; its price is directly dependent on the value of the primary commodity or upon any decided pricing arrangement or index. Derivatives involve the trade of obligations or rights based on the underlying primary product however; it does not directly involve transfer of property.

Commodity derivatives are essentially trade contracts based on the underlying asset which is the commodity and the investors speculate on these, based on the expected price movements in the future. Primarily this market has three classes of participant's namely Hedgers, Speculators and Arbitrageurs.

1.6 Types of Commodity Markets:

1.6.1. Cash Market:

The market wherein there is prompt delivery of a commodity for a specified price between the seller and buyer based on cash transaction is referred as a cash market. Basically it involves the trade based on settlement of the transaction in terms of cash. The peculiar feature of this market is that it is a traditional market wherein the seller and the buyer meet physically and then the transaction is clinched. The cash market involves the actual payment of cash resulting in prompt delivery of the commodities.

1.6.2. Derivatives Market:

The market wherein there is exchange of derivatives taking place is referred as a derivative market. Derivatives market could be further classified into commodity derivatives market and financial derivatives market. Commodity derivatives market involve trade contracts wherein the underlying asset is a commodity and financial derivatives market involve trade contracts which have financial asset or variable as the underlying asset. Derivatives are tools employed to eliminate or reduce the price risk resulting from future price movements.

1.7 Features of Commodity Derivatives Market:

1. **Standardized**: Commodity derivatives contracts are of standardized predetermined quantity, quality, and delivery date.

2. **Organized:** Commodity derivatives contracts are traded on an organized commodity exchange in India like MCX, NCDEX etc. and LME, NYMEX etc. internationally.

3. **Facilitates Margin Trading:** Trading in commodity derivatives do not involve investment of the full value of a contract but the traders are required to keep a margin ranging between 3% to 8% of the total value of the contract which varies across commodities and exchanges. This facilitates the traders to take benefit of leveraged positions.

4. **Physical Delivery**: Commodity derivatives trading have the option to take actual delivery of the commodity on expiry of the contract. Physical delivery of the commodities requires providing by the member to the exchange prior delivery intimation and completion of all the formalities related to delivery as stated by the exchange.

5. **Regulated Markets Environment:** Futures markets are being regulated by the Government through SEBI in India and Commodity Futures Trading Commission (CFTC) in USA, etc. which ensures fair practices in the commodity derivatives market.

6. **Eliminates Counterparty Risk:** Commodity derivatives exchanges take the help of clearing houses to reassure fulfilment of the terms of the futures contract thereby avoiding the risk of default by the other party.

1.8 Merits of Commodity Derivatives Market:

The main objectives of any commodity derivatives exchange is efficient price risk management and price discovery. The end beneficiaries constitute people who trade in the commodities being traded in the commodity exchange and also those who are not directly involved with futures trading. It is because of risk management and price discovery through the existence of futures exchanges that many of services and businesses are able to function efficiently.

1. **Price Discovery:** Based on information regarding specific marketing formation, Government policies, the demand and supply equilibrium, comments, inflation rates, market dynamics, weather forecasts, expert views, hopes and fears, buyers and sellers

conduct trading at the commodity derivatives exchanges. This leads to continuous price discovery of the commodities.

2. **Price risk management:** The most frequented method of price risk management is hedging. It involves offering price risks that is part of spot market by taking a same but opposite position in the commodity derivatives market. Derivatives markets are used as a means by hedgers to protect their business from bad price changes which could affect the profitability of the business. Commodity derivatives market helps the commodity market participants to distance from price risk by using hedging techniques which shows the efficiency of the commodity derivatives market.

3. **Benefits to agriculturalists/ farmers**: Price fluctuations have a direct impact on farmers in the absence of commodity derivative market. Large reserves to insure against adverse market condition are not required. The main focus of the derivatives exchange market is to ensure availability of the prices which will be of immense help to the farmers. On account of the time lag between planning and production, the market fixed prices data is disseminated by commodity derivatives exchanges which would be relevant for their decisions regarding production.

4. **Predictable Pricing:** Certain commodities have demand which is highly price elastic. The producers have to see that the prices do not fluctuate so that it would protect their market interest without restrictions on imports. Derivatives contracts will facilitate predictability of local commodity prices. The producers can anticipate the impact of the price changes reasonably well. Without the derivatives market, the producer could be in the trap of short term price changes which require adequate financial reserves which otherwise could be used for alternative profitable investments.

5. **Import- Export competitiveness:** The commodity derivatives market helps the exporters to hedge their price risk and improve their competitive strength. The physical market exposes them to the price risk which could result into losses. The existence of

commodity derivatives market facilitates the exporters to hedge their intended purchase by short term substitution for actual purchase till the time is appropriate to purchase in spot market. Without the derivatives market it will be time consuming, meticulous, and costly physical transactions.

6. Improved product quality: The warehousing and grading facilities along with other associated advantages suggest that there is need to upgrade and improve the quality of the commodity that is expected by the commodity exchange. This results in uniformity and standardization of commodity exchange trading.

7. Credit accessibility: Without appropriate risk management tools, processing and marketing of commodities would be exposed to high risk which makes it a risky business to be funded. This will result in higher interest rates and stringent terms and conditions. Commodity derivatives markets would reduce the discount rate in commodity lending through hedging.

1.9 Commodity Market Participants:

1. Hedgers: are those whose interest is in the ready delivery or specific delivery contracts and are basically taking advantage of commodity derivatives market to protect themselves against price changes. Their main aim is to insure themselves against the risk which is part of the price of the asset by taking advantage of the derivatives. Hedgers are in need of certain parties who are ready to take the opposite party position.

2. Speculators: They are like middle man. They basically do not have special interest in the underlying commodity, but waits for opportunity in the price changes favourable to them. Their interest is not to own the commodity. They are ready to take the risk which the hedgers want to pass on in the derivatives market. They buy from one and sell it to others in the hope of future price changes. They facilitate the required liquidity and depth to the market which the hedgers on their own fail to provide. The speculators are primarily

experts in analysing the market and shoulder the risk of the hedgers for anticipated profits thereby providing a helpful economic function and are an important constituent of the commodity derivatives market. Without the speculators, the commodity derivatives market will not have liquidity and have chances of a collapse.

3. **Arbitrageurs:** are those who make the decision of simultaneous purchase and sale in two different markets so as to reap the benefit of price differences. Indirectly, they help eliminate the price differences in different markets. The arbitrageurs facilitate in bringing the prices of contracts across in a commodity in equilibrium.

The other substantial constituents in commodity markets include:

1. Commodity Traders: Commodity markets have complicated trading processes. Traders make efforts to include value to trading relationship by facilitating risk management traits. Traders also sometimes offer financing and other services. Commodity traders have cumbersome hedging needs, which depend on the peculiar type of their activities.

2. Commodity Consumers/ Producers: These constituents have natural underlying outright short (consumers) and long (producers) positions in the relevant commodity. The risk which is part of the exposure drives the applicability of commodity derivatives by consumers and producers.

The use of commodity derivatives is mostly because of the pattern of cash flows. Producers need to make substantial capital investments to commence the production of a particular commodity. This particular investment decision is mostly made well before the sale and production of the commodity. This implies that the producer is well aware of the price changes in the commodity.

The consumers need to decide on hedging is necessitated by the availability of alternative products and the capacity to transfer the increased input costs. In many of the commodities, consumers and producers deal directly with each other. The contracts include negotiated

one to one long term purchase or supply contracts with the consumers and producers. The contracts may involve fixed price agreement to ensure decline in the price risk for consumers and producers.

These agreements result in a number of obstacles. These include exposure to counter party credit risk, lack of transparency and low liquidity. The bilateral structure results in creating expected bad performance incentives. This shows the fact that the contracts integrate purchase/supply obligations and price risk constituent in a particular contract.

3. Commodity Processors: These participants have constraints of immediate price exposure. This shows that the processors have a spread opened to the price changes between the amount of the input and the amount of the output. For example, oil refineries are open to the differences in the price of the crude oil and the price of the refined oil products namely heating oil, aviation fuel, diesel, gasoline, etc.

4. Investors: This includes financial investors who search to invest in commodities as a separate asset class and distinct financial investment. Commodities are being gradually recognised as a specific class of investment which is a substantial factor that has favoured the structure of commodity derivatives markets.

5. Financial Institution/Dealers: Dealers participate in the commodity markets mainly as provider of risk management products and as a provider of finance. The dealers part is akin to that in the derivative market in the other classes asset. The dealers basically provide immediacy of execution, credit enhancement, structural flexibility and speed. Dealers mostly include risk management products such as provision of finance which is part of other financial services.

1.10 Historical Evolution of Commodity Derivatives Markets:

1.10.1 Global Scenario Commodity Derivatives Market: The organized trading in commodity derivatives market can be traced to United States of America (USA) in the middle of the nineteenth century with maize contracts being traded at the Chicago Board of Trade (CBOT). And later on, cotton contracts were traded in New York. In later years, Chicago was known as a main centre with telegraph lines, railways and roads connecting it with the rest of the parts of the country and world. This attracted wheat producers from middle-west to come and sell their output to the distributors and dealers. Due to the problems like absence of uniform grading system and proper storage facilities producers were at the mercy of the dealers. This resulted in the need to arrange a common meeting place to facilitate the dealers and producers to conduct business on the spot which involved delivery of wheat and receipt in return of cash. In the year 1848 a market place was opened wherein dealers and producers could meet and deal on cash basis. Gradually, producers started to enter into forward contracts which were suitable for both dealers and the producers in the sense, the dealer knew the cost of procurement and producer knew the price for the output much in advance. This type of forward contracts became common with use of the same as security for loans. In due course of time the contracts became standardized in terms of quality and quantity of the commodities being traded.

In the beginning of the 20^{th} century, with advancement in transportation and communication, centralized warehouses were constructed to economically distribute the goods. The major trading was agricultural commodities which later led to further trading in other non agricultural commodities. The years 1870s and 1880 saw the birth of the New York cotton, coffee and produce exchange. The Chicago Mercantile Exchange, the Chicago Board of Trade, the New York Commodity Exchange and the New York Mercantile

Exchange are the largest commodity exchanges in USA. The leading commodity markets in the world are:

1. Chicago Board of Trade (CBOT) set up in 1848
2. The New York Cotton Exchange established in1870
3. Chicago Mercantile Exchange was started in 1919
4. New York Mercantile Exchange
5. New York Board of Trade
6. London Metal Exchange
7. Sydney Futures Exchange
8. Tokyo Commodity Exchange
9. Dubai Gold and Commodity Exchange
10. Shanghai Futures Exchange
11. Singapore Commodity Exchange
12. Zhenghou Commodity Exchange
13. Osaka Mercantile Exchange
14. Brazilian Mercantile and Futures Exchange
15. Inter Continental Exchange

1.10.2 Indian Scenario of Commodity Derivatives Market: In India trading in commodities has its early roots many centuries ago. Commodity derivatives is not alien to India, as commodity forward trading had its presence in 1875 with contracts in cotton by the Bombay Cotton Trade Association. Food grain and oilseeds futures was traded later and prior to World War II, trading in futures in commodities such as raw jute, jute products groundnut oil, wheat, rice, castor seed, sugar and as well as precious metals was traded. Derivatives trading were prohibited during the World War II to contain illegal hoarding and higher speculation. The Forward Contracts (Regulation) Act was enacted after

independence in 1952 to regulate the trading in futures and forwards. The development and regulation of the commodity derivatives market is vested with the Central Government.

The Prof. A.D. Shroff and parliamentary select committees referred a bill on forwards contracts and the Forwards Contracts (Regulation) Act was passed by the parliament in December 1952 with the Forwards Markets Commission (FMC) being set up in 1953 to regulate the commodity market. The Central Government notified the Forwards Contracts (Regulation) rules in 1954.

However the Indian commodity markets did not grow over the following four decades as the Forwards Markets Commission (FMC) viewed the commodity markets with suspicion that futures trading was leading to speculation. Price control was the main focus of economic policy during most of this period. The scarcity of many commodities and minimum support price offered by Government hindered the development of the commodity derivatives market. The fragmented physical/spot market coupled with various taxes and Government laws hindered the free movement of commodities leading to acting as a major hindrance for the development of commodity derivatives markets in India.

In 1966, the already impacted commodity derivatives market suffered a major setback when, futures trade was banned to give major powers to Government towards price management. Later certain commodities derivative trading was reintroduced after the Shroff Committee in the year 1950, the Dantewalla Committee in the year 1966 and in year 1980 the Khusro Committee recommended the same.

The actual breakthrough in commodity derivatives trading came in the early 1990s with the liberalization of the Indian economy. In 1993, the Kabra Committee which was appointed to look into commodity derivatives market recommended that all futures trading which was banned in 1966 be reintroduced, with additional products being added to the list. Later after six years, the National Agricultural Policy 2000 suggested the removal of the price controls measures in agricultural markets and extensive application of derivatives contracts. The

commodity derivatives market got major push in 2003, with establishment of national commodity exchanges. It was indeed a appropriate decision too, as in the international scenario the commodity derivatives markets were on the upswing and the future decades were being suggested as the decade of the commodities.

The commodity derivatives market has evolved as one of the fastest growing commodity derivatives markets in the world, since 2003 with the reintroduction of commodity derivatives trading in India. India is among the major grower of commodities and at the same time consumes major amount of energy and bullion products. Given the growth in trading volumes and increasing integration of the Indian economy with the rest of the world, the Indian commodity derivatives market has began to be recognized among the top derivatives exchanges of the world thus making it one of the most high growth areas in the financial sector today.

1.11 Structure of Commodity Market in India Prior to FMC-SEBI Merger:

The Forward Contracts (Regulation) Act, 1952 was passed after independence which had the forward contracts being regulated in commodities all over India. The Act was applicable to goods, which were defined as any a movable property apart from currency, security, and actionable claims. Options trading in commodities were prohibited by the Act. Under the Act, exchanges which were recognized by the Government and were allowed to permit forward trading in the regulated commodities.

The Act provided for three- tier regulation:

(i) The Forward Markets Commission(FMC) would provide the regulatory supervision under the powers given to it by the Government

(ii) The Exchange which allowed forward trading in commodities could also regulate trading daily

(iii) The Department of Consumer Affairs, under the Ministry of Consumer Affairs, Food & Public Distribution, is the final regulatory agency.

1.12 Merger of the Forward Market Commission (FMC) with Securities and Exchange Board of India (SEBI):

In the Union Budget for financial year 2015-16, the Central Government proposed merger of Forward Markets Commission (FMC) with the Securities and Exchange Board of India (SEBI) from September 28, 2015. The merger would facilitate convergence of rules, taking advantage of economies scale for the exchanges and other stakeholders.

SEBI has expertise in efficiently regulating the securities market over 25 years and the extensive powers to regulate the markets. With the commodity derivatives market being brought under SEBI it is expected that the commodity derivatives market will be on par with the securities market in terms of new products and participants, technology, risk management, regulations, surveillance, enforcement framework, regulation/code of conduct for intermediaries, investor protection and supervision.

Subsequent to the Central Government notifications namely F. No. 1/9/SM/2015 S.O. 2363 (E) and F. No. 1/9/SM/2015 S.O. 2362 (E) under the powers bestowed by Finance Act, 2015, the FMC was to be merged with SEBI on 28 September, 2015 and the Securities Contracts (Regulation) Act, 1956 subsequently underwent amendments to add commodity derivatives and the Forward Contracts (Regulation) Act, 1952 (FCRA) was scraped. For the purpose of gradual transition and facilitating the merger process, SEBI undertook steps after the announcement by the Central Government and undertook the following steps:

A. Merger Planning

1. SEBI formed different committees and commodity cell senior officials being posted who were given specific task of preparing a road map and successful implementation of the

process of merger and also coordinate with other departments and entities. There were consultations with international experts in the securities and commodity derivatives markets.

2. SEBI facilitated interaction with international regulators/exchanges through video conferencing/ teleconferencing to understand the regulatory framework for commodity derivatives markets in other countries

3. SEBI apprised the International Advisory Board (IAB) about the implementation progress of the merger process. IAB in turn suggested that the focus during preliminary stage of merger must be on taking care that there is no crisis in the commodity derivatives market and further steps to be taken after evaluating the weaknesses and strengths of the commodity derivatives markets.

B. Gap Analysis

1. SEBI undertook the gaps between the SEBI norms/regulations in equity and equity derivatives market with that of the norms/ regulations in commodity derivatives markets.

2. Necessary amendment were done in the SEBI (Stock Brokers and Sub-brokers) (Amendment) Regulations, 2015 and Securities Contracts (Regulation) (Stock Exchanges and Clearing Corporations) (Amendment) Regulations, 2015.

C. Organizational Structure

1. A separate department named 'Commodity Derivatives Market Regulation Department' (CDMRD) was created to facilitate integration of work culture of FMC with SEBI.

2. The other departments such as Department of Economic Policy and Analysis (DEPA), Market Intermediaries Regulation & Supervision Department (MIRSD), Investigations Department (IVD), Integrated Surveillance Department (ISD), Enforcement Department (EFD) and Legal Affairs Department (LAD) the work related to

commodity derivatives market was completely merged at department level by facilitating and allocating dedicated divisions.

3. The manpower requirement for these new divisions /departments was facilitated by having mix of officers from SEBI and FMC to ensure expertise and continuity in regulatory framework for the commodity derivatives market.

D. Risk Management

1. SEBI issued guidelines for base minimum capital, margin calculations, margin collection, concentration limits, acceptable forms of liquid asset deposits etc. to streamline margining framework and risk management for the national level commodity derivatives exchanges.

2. SEBI prescribed risk management requirements for regional commodity derivates exchanges.

3. SEBI ensured surveillance of the commodity derivatives market by bringing the surveillance of the commodity derivatives market on par with the equity markets. SEBI also ensured that connectivity was established with national commodity derivatives exchanges and data acquisition equipment's were installed which facilitated integrating DWBIS (Data Warehousing and Business Intelligence System) surveillance systems and trading data with IMSS (Integrated market Surveillance System) of SEBI. The data integration supported generation of Commodity market alerts and reports in IMSS and SWBIS systems.

E. Capacity Building

1. SEBI conducted workshops and presentations with Commodity Derivatives Exchanges/ FMC/ Market experts/ consultants/ Commodity Derivatives Brokers to understand the operations of commodity derivatives market and its ecosystem.

2. SEBI team of officials visited commodity market ecosystem such as warehouses, exchange, vaults, mantis etc. to understand the process of deposit, storage and delivery of commodities.

3. SEBI officials also conducted training on the commodity derivatives markets by experts from the commodity derivatives market.

1.13 Timeline of Commodity Derivatives Market reforms after SEBI-FMC merger:

The commodity market regulator FMC was merged with Securities and Exchange Board of India (SEBI) in September 2015 to create a single regulator for commodity and equity markets. Since the merger, SEBI has announced major reforms for the commodity markets. Subsequent to the merger of Forwards Market Commission with SEBI, SEBI has taken various steps to streamline and strengthen the rules applicable to the commodity derivatives market as at the same time guide the different stakeholders of the commodity derivatives market in India to the regulatory requirements of the Securities Contracts (Regulation), Act, 1956

29 September 2015: SEBI introduced new eligibility and net worth requirements to register the commodity derivatives exchanges. The requirements are same as required for the trading in equity and all the registered members were required to be compliant with the eligibility norms.

01 October 2015: SEBI has introduced stricter risk management structure for national commodity derivatives exchanges with regard to assets in setting up an exchange, net worth criteria, margin requirements, settlement guarantee fund, base minimum capital etc. The norms are similar as those needed by the equity exchanges and implementation was supposed to be by 1st January 2016.

21 October 2015: SEBI introduced a separate risk management requirements for the regional commodity derivatives exchanges.

26 November 2015: SEBI issued dates to all commodity exchanges to adhere to the formalities of Securities Contract (Regulations) Act, including norms on regulatory fee, corporatization and demutualization, ownership, cleaning and settlement, governance, net worth, delisting, dematerialization of securities, formation of various exchange-level committees etc.

9 December 2015: SEBI directed commodity exchanges to submit monthly development reports, commencing from April 2015.

11 January 2016: SEBI introduced the exit requirements for commodity exchanges.

29 January 2016: SEBI reduced position limit and month open position limits at both member and client level for all agricultural commodities.

17 March 2016: SEBI allowed commodity derivatives trading at the International Financial Services Centers (IFSC). Stock exchanges which were functioning in IFSC are permitted to trade in commodity derivatives. The SCRA was amended to include commodity derivatives as "eligible securities", which implies that institutions such as mutual funds and foreign portfolio investors could invest in the commodity derivatives market. However, the mutual funds are yet to be amended their rules to facilitate participation of institutional investors in the commodity derivatives market.

29 March 2016: SEBI introduced stricter cyber resilience framework and cyber security for the commodity exchanges to improve monitoring standards, protection and governance. The new norms were to be effective from 01 January 2017. SEBI also made the modification of client codes after execution of trades in any commodity exchange.

25 April 2016: SEBI ordered compulsory disclosure of the property trading by commodity brokers to their clients to improve transparency in the dealings between clients and stock brokers in commodity derivatives market.

11 August 2016: SEBI made mandatory system of audit of stock brokers and trading members annually of national commodity derivatives exchanges, which is same as the equity space.

19 August 2016: To facilitate more active participation in the commodity derivatives market, SEBI allowed exchanges to grant hedge limits and offer incentives to hedgers to their clients and members which is in addition to the usual position limit sanctioned to them.

30 August 2016: SEBI directed commodity exchanges to communicate derivatives prices through SMS and any other electronic channel like email, instant messengers etc for the commodities which are subscribed on a daily basis free of charge.

02 September 2016: SEBI ordered exchanges to adopt stricter spot price polling system for commodities and improve disclosures relating to such system.

7 September 2016: SEBI stipulated the first trading day limit and daily price limits for non-agricultural commodity derivatives trading.

20 September 2016: SEBI suggested stricter requirements for commodity futures to qualify to be traded on the commodity exchanges on a continuous basis. Tougher requirement with regards to change of contracts is incorporated to avoid sudden change in contract terms of abrupt stoppage of futures contracts. SEBI prescribed exchanges not to change anything in a ongoing trading contract without prior intimation and a approval from SEBI.

26 September 2016: SEBI strengthened the investor protection fund requirements for the commodity exchanges.

20 January 2017: SEBI floated a discussion paper asking suggestions on ways to price and settle commodity options contracts.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Literature Review:

The commodity derivatives market and its impact on equity market have been studied by different research scholars. The studies have been undertaken in different countries and India. The literature available on commodity derivatives market and its impact on equity market have been listed as under:

Narendra L. Ahuja (2006) studied the commodity derivatives market and reinforced that developing countries policy makers need to allow market forces to dictate prices and propagated price risk management rather than going against the tide by trying to achieve this through administered price mechanism. The author believes that price risk management impact the propagation of trade and lower trade barriers globally in the future.

Lokare S.M. (2007) carried out a study on commodity derivatives prices prevailing during the period from 1990 to 2005 and made an attempt to study its impact on price risk management. The author provides ample evidence of the co-integration of spot and future prices. The study concluded that in the case of some countries the volatility in future prices was much lower as compared to spot prices and this indicates inefficient utilization of available information. Besides, several commodities seemed to attract widespread speculative trading. Hedging was found to be effective with reference to some commodities, however other methods involved moderate to considerably higher quantum of risk.

Meenakshi Malhotra (2012) utilized quantitative analysis to research price discovery which is one of the main functions of commodity derivatives market. Even though India enjoys a good global ranking in trading volumes for commodities like gold, silver, gaur seed, copper etc it's functioning is skewed due to inability to understand the dynamic nature of the markets. This study concluded that there is urgent need to deliberate on issues that

require to be researched so that healthy growth and development of the markets can be promoted efficiently.

Brajesh kumar, Priyanka Singh and Ajay Pandey (2008) studied the commodity and stock markets with special emphasis in seasonality in risk returns, volatility and risk premium. General Auto Regressive Conditional Hetroscedasticity (GARCH) has been used in the mean model and model volatility in returns has been presented using a systematic approach. The study closely examines the asymmetric nature and volatility clustering in the Indian commodity and stock markets. Seasonality in risk return and risk return relationship has also been investigated. An empirical study of market index S & P CNX Nifty and various commodities for different periods have been done. The study concludes that stock and commodity markets display persistence, clustering and asymmetric properties. Seasonality in returns and risk indicates asymmetric nature of returns that is there is a negative correlation between risk returns and its volatility.

Parantap Basu and William T. Gavin (2011) investigated hedging opportunities for the investors in the United States during the period from 1994 to 2008 using trend analysis by studying the correlation between futures and stock returns. The steep increase in commodity derivatives trading has expanded the whole derivatives trading market. The study concludes that the negative correlation between commodity futures and equity return could be as expected and equilibrium phenomena in an environment does not offer any unexplained hedging opportunities and harvest profits.

Alok Kumar Mishra (2008) investigated the current status and growth inhibiters that are acting as obstacles in the Indian commodity future markets. The advantages of dealing in commodities as compared to a portfolio of equities have been tested. The study covers the

period from June 2005 up to November 2007 and uses statistical analysis very effectively. The author emphasises that a more pragmatic and focussed approach is needed from the Government, the exchanges and the regulator to bring vibrancy into the commodity derivatives market for risk management. The study concludes that MCX Agriculture futures are good diversifying agents whereas MCX Energy futures fail to show diversification benefits to equity portfolios.

Yamori Nobuyasghi (2011) used Japanese market data and examined whether commodity markets have played a significant role as alternative investment opportunities having different risk characteristics as compared to traditional assets. This study has been done by using trend analysis and correlation analysis utilising data from May 1986 to Feb 2007. It concludes that earlier growth of the commodity market used to be negative or hovering around zero prior to the year 2006, however after the global financial crisis of 2008, growth has surged ahead considerably and thereby lost its edge for portfolio diversification.

Anurag Agnihotri and Anand Sharma (2011) used data collected from MCX and NCDEX to study the relationship between spot and future prices of commodities like zinc, natural gas, chana and jeera. The study concludes that a positive correlation exists between spot and future prices of the selected commodities. The results obtained clearly indicates that the correlation coefficients by themselves are unable to detect convergence, however a more powerful tool like regression linear test detects convergence between spot and future prices of the selected commodities more significantly.

Manta Kumar Mahalik, Debashis Acharya and M. Suresh Babu (2010) conducted a study by utilising four spot and futures indices of MCX to examine the volatility spillover and price discovery in the Indian commodity market during the period from the year 2005

to 2008. The VECM findings indicate that the spot market price discovery function is based on developments affecting LAGRIFP, LENERGYFP and LCOMDEXFP. This in turn implies information flows from the future to the spot commodities market. However the reverse causality is absent. The authors have used Bivariate GARCH model to show that an innovation in a market could prompt volatility in another market.

Srinivasan P. and Ibrahim P. (2012) examined the process of price discovery and volatility spill over during 2009 to 2011 with regards to gold spot and future markets on NCDEX. The author has used appropriate statistical tools to prove that gold spot market plays a dominating role and is an effective vehicle of price discovery. The study also concludes that information spills over from spot to futures market and the innovation in information processing can expose all the latest information with respect to the gold spot market.

Hany A. Shawky, Achla Marathe, Christopher L. Barrett (2003) analysed wholesale electricity future and spot prices during the years 1996 to 2000 for significant statistical properties. The authors have used statistical tools like GARCH model, VAR model and ARCH model to conclude that the electricity market follows similar patterns as other efficient markets. Auto correlation results of future and spot series have been used to prove the same, however they also conclude that there is a significant difference in electricity futures as compared to other commodities as far as hedge ratios and estimates of future premiums are concerned.

Pankaj Kumar Gupta and Sunita Ravi (2012) analysed the price discovery function and volatility spill over in relation to the future and spot commodity markets for the time period between 2005 to 2011. The closing spot and future prices on NCDEX Ltd for Chana have

been analysed using statistical tools like Vector error correction model, Johansen's co-integration test, unit root test and EGARCH model. The authors concluded that with respect to commodities the future market is more efficient when compared to the spot market and that the future market aids the spot market in the price discovery process.

Brijesh Kumar and Ajay Pandey (2011) investigated and analysed the cross market linkages with respect to nine commodities from the Indian futures commodity market with future markets from other countries. The commodities selected covered metals, energy, precious metals and agricultural products. The authors studied the return spillover using Granger causality test, Error correction model, Johansen's co-integration test and variance decomposition techniques. The volatility spillover between India and other markets were studied using GARCH model. The paper concluded that there is co-integration in future prices and that world markets greatly impact Indian markets. The authors detected a return spillover between LME and MCX, of bi-directional nature. An interesting finding of the study was that the effect of LME on MCX was more prominent then that of MCX on LME. Also, the volatility and return volatility spillover point to the fact that the Indian commodity futures markets play the role of a satellite market and the world markets provide it with inputs.

Chellasamy P. and Anu K.M. (2015) studied the relationship between the future and spot prices of commodities like zinc, copper, gold, silver and crude oil during the time period from 1st January 2014 to 28th February 2015. The authors have used Johansen co-integration test, Granger causality test and ADF unit root test to analyse co-movements between the future and spot price returns of commodities on MCX. The study concluded that the price movements of commodities during the period of study were independent of each other.

Ajay Kumar Chauhan, Shikha Singh and Aanchal Arora (2013) analysed the Indian commodity markets volatility spill over effects between future and spot markets for agricultural commodities chana and gaur seed. It also studied the market inefficiencies of the Indian commodity market covering the period from 1st April 2004 to 31st March 2012. The Phillip Perron, KPSS tests and ADF unit root test were used to investigate the existence of unit root within the price series. They observed the presence of extended term equilibrium association between the future and spot market of the commodities. The Vector Error Correction Model (VECM) was used to examine the error correction mechanism and detected that disturbances to the equilibrium relationships of the market can be mapped. The authors used the GARCH (1,1) test with squared lagged residuals of another exogenous variable series was utilized to examine effects of volatility spillover between futures and spot prices with special reference to agricultural commodities. The findings showed that commodity derivatives markets can lead the price discovery function with reference to the spot market, which indicates that there is dissemination of information from the futures to the spot commodity markets. They also concluded that although innovations in one market may enable the prediction of volatility in the same other market, the volatility spillovers originating in the futures enroute to the spot market will be dominant.

Prashanta Athma and K.V. Venugopal Rao (2013) utilised data from Comdex to examine the temporal link between the future and spot prices in the commodity market. Statistical tools Johansen Co-Integration Test, Multiple Regression, Augmented Dickey-Fuller Test Statistic, Vector Error Correction Model and Granger Causality Test have been used for data analysis. The study reveals that the market display high efficiency in price formation with respect to transmitting information linking both the markets. The Comdex data showed that the mean future prices are higher as compared to the mean spot prices and that this phenomenon could be attributed to the fact that Comdex combines both perishable

as well as non-perishable commodities. The futures played a lead role in the markets and strongly influenced the predictions of spot prices. Similar conclusions were observed and confirmed when the Granger causality and Vector error correction model were used. They concluded that markets as a whole are efficient and the availability of Comdex data can enable traders to hedge their risk across a much larger canvas.

Viswanathan T. and Sridharan G. (2014) investigated the causal relationship linking the prices of pepper in the future and spot markets. For the purpose of the study the day to day closing prices of pepper in the spot and future markets on NCDEX during the period from 2005-2006 till 2012-2013 were collected and used as input. The associations linking these two series of data were tested by the application of Granger Causality test. Jarque Bera test and descriptive statistics were applied to analyse the characteristics of time series data distribution of future and spot price of pepper. Correlation analysis was used to detect auto-correlation within the series. Augmented Dickey Fuller test was applied to the time series of future and spot prices of pepper and it showed that the prices at first order level were stationary. The Granger Causality test were applied to analyse the relationship between future and spot prices which showed that there existed bilateral causality linking the spot and future prices of pepper.

Tanushree Sharma (2015) have scrutinized the short and long term causality between the futures and spot prices of six agricultural commodities on NCDEX namely, soyabean, soya refined, potato, pepper, Guar gum and Chana. The study showed evidence of strong co-integration between spot and future commodity prices of potato and Guar gum. Vector Error Correction Model was used after duly identifying single co-integration between spot and future commodity prices of the six commodities to examine causality nexus, which was found to be consistent with market efficiency indices. Also, Wald test and VECM model

was used to measure the short run and long run causality between the commodities. The author concluded that soyabean and soya oil futures lead to spot, whereas bi-directional relationship was detected in case of pepper and chana.

Sanja Sehagal, Wasim Ahmed and Florent Desting (2014) have studied the information transmission process in the Indian agriculture commodity futures market by scrutinizing directional volatility spillovers and price discovery between spot and future prices on MCX and NCDEX of selected nine commodities. The study scrutinised data from the period from 1 January 2009 upto 31 May 2013 on a daily basis. The study concludes that indeed price discovery links spot and future prices, thereby confirming the detection of definite information flow. In the short run volatility spill over results showed a very strong volatility spillover, the direction being from spot to the future market, however in the long run the direction of the spillover was found to be in the exact opposite direction. The plotted results imply that the level of the volatility rooted information spillover is not very significant in the Agriculture future market. It was found that volatility spillovers are not inter-commodity, they are chiefly intra-commodity, the exception being soyabean and refined soya. The study concludes that agriculture commodity derivatives market has been evolving in the correct direction of late and the futures market has become the pivot of the information transmission process.

Krishna Singhal (2014) studied the linear causal linkage connecting the daily future and spot prices of crude by utilizing the data spanning the period commencing from 1st January 2009 up to 31st December 2011. The data was analysed and verified by ADF unit root test, whereas the lead lag affiliation linking future and spot prices was investigated by Granger Causality Test. This study concluded that future price leads the spot price i.e. the futures

price of crude oil price can be effectively used to predict its spot price and the price discovery in the futures market is much faster when compared to the spot market.

Srinivasan P. (2012) used the bivariate EGARCH model, Vector Error Correction Model and Johansen co-integration test to investigate the volatility spillovers and price discovery mechanisms in the Indian commodity markets. The author has studied four future and spot commodity markets of MCX namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL including areas of agriculture, metals, energy. The Johansen co-integration test confirmed the existence of long term symmetrical relationships amidst the future price and its corresponding spot price.

Sanjay Sehgal, Namita Rajput and Florent Deisting (2013) studied the volatility spillover in the Indian commodity markets. The research encompasses twelve very actively traded commodities which included energy, agriculture and metals in addition to four commodity indices. The existence of prices discovery process was proved for eight commodities and for three commodity indices which indicated a larger role for the future markets within the price discovery process. The results thrown up by price discovery were heartening when compared to the nascent nature of Indian commodities markets. The study confirms the fact that Indian commodities market lacks effective risk transfer mechanism for most commodities. These findings have definite implications on all stockholders namely investors, hedgers and policy makers.

Jabir Ali and Kriti Bardhan Gupta (2011) selected and analyzed the efficiency quotient of agricultural commodity markets through the assessment of associations between spot and future market prices. For the purpose of the study, twelve agricultural commodities traded on NCDEX were studied to analyze efficiency in the future markets. The authors have

used Phillips-Perron and Augmented Dickey-Fuller unit root test, Granger causality test and Johansen's Co-integration test. The Co-integration test suggested the presence of extended long term association linking future and spot prices of majority of the agricultural commodities. The outcomes suggests that the future market has a stronger ability to forecast subsequent spot prices of castor seed, sugar, soyabean and chickpea as compared to pepper, black lentil and maize wherein a bidirectional relationship existed in the short term.

Jackline S. and Malabika Deo (2011) investigated the link between the spot market and future market for the pork bellies and lean hogs showing the time period from January 2001 up to May 2010 and quantified the price discovery utility of commodity futures prices as against spot prices in the sample markets. The authors employed econometric tools like Pairwise Granger Causality tests, Unit root tests, Phillips-Perron test and Augmented Dickey Fuller test. The study concluded that both the chosen markets are stationary series. The Granger Causality test indicated existence of bi-causality relationship amongst these markets. The study further concluded that both the markets were in perfect equilibrium and that no profitable arbitrage existed in both these markets.

Gorton and Rouwenhorst (2006) have put together their own index for commodity futures covering the period from 1959 to 2004 and scrutinized how it compared with returns obtained from bond and stock indices. Their conclusion was that the collateral future index gave an annualized return that was very much alike that of S & P 500 over the entire period and that corporate bond got outperformed by both assets. They found that relative performance varied with time and that the commodity diversification benefits were workably when they are most needed. Based on these findings, they have arrived at their final conclusion that diversified portfolios can be created with commodity derivatives.

Conover, Jensen, Johnson and Mercer (2010) studied a sample of investors over a time span of 36 years and concluded that commodity investments give attractive benefits irrespective of their investor's style of investing. They have brought out an interesting fact that adding commodity exposure can boast equity portfolios returns especially when interest rates are increased by the Central Bank. This is consistent with the assumption that commodities are a major attraction as they hedge inflation.

Buyukahin, Haigh and Rebe (2008) studied whether traditional financial assets and commodities move in synchronization with each other. They informed that over the last 15 years the relation between U.S equity indices and investible commodities had remained unchanged. They did not find any secular enhancements in co-movements between commodity investments and returns on equity even during periods of highly fluctuating returns.

Gurbandini Kaur and Rao D.N, (2010) studied the market efficiency of trades at NCDEX during the time period July 2008 to July 2009, for select agricultural commodity derivatives. The findings showed significant linear dependence for all the selected agricultural commodities. The whole sample period showed that both spot and future price of all the selected agricultural commodities are very weakly efficient.

Chris Brooks & Marcel Prokopczuk (2010) scrutinised the stochastic behaviour of prices for the period January 1985 - March 2010, from two perspective namely individual commodity perspective and commodity cross market linkages perspective. They concluded that related commodities from the same market segment had the highest returns correlations. On the other hand commodities of unrelated segments were found to be insignificant. They also found that the return correlation between equities and commodities

are very low and for this reason commodities are considered as diversifiers for traditional portfolios of bonds and stocks. They also concluded that volatilities of commodities and equity are to a large extent uncorrelated. Commodities serve both as a volatility diversifier and return diversifier simultaneously.

R. Salvadi Easwaran and P. Ramasundaram (2008) studied commodity futures market to assess its efficiency and its role in price discovery. They employed econometric analysis of price behaviour and price volatility and of futures and spot markets by selecting few agricultural commodities from NCDEX and MCX. They also found the bottlenecks of agricultural commodity trades and recommended policy measures for improving the Indian futures market. They concluded that futures markets are inefficient, which in turn implies that futures exchanges do not provide an efficient hedging mechanism against the risk arising from the price volatility. The implications being that price discovery is not prominent in the agricultural commodity futures market.

James Chong and Joelle Miffre (2008) weighed the conditional correlations between commodity traditional securities and commodities future returns using GARCH-DCC model. They concluded that conditional correlations between S& P 500 and commodity futures fell over a period, which indicated that commodity futures have evolved its better tools for allocation of strategic assets. The correlations with returns on equity also saw a fall in time periods of above than average equity volatility.

Ahmed Imran Hansjra, Mohammed Azam, Ghulam Niazi, Babr Batt, Kashit – Ur – Rehman & Rant Azam (2011) researched the return and risk relationship in commodity and stock markets of Pakistan They studied sugar, gold and cotton prices together with month wise closing stock prices (KSE 100 Index) from July 1998 up to July 2008. The

findings which were computed by using GARCH, GARCH-M and EGARCH showed that seasonal and asymmetric effect is there in stock market and commodity market, however, seasonal effect and asymmetric properties are most dominant in stock market prices as compared to other commodities, this implies that good or bad news impacts stock market returns negatively or positively.

Tausi Kawameto, Takeshi Kimura, Keataro Morishita & Masato Higashi (2011) studied the reasons for the recent surge in commodity prices globally and investigated the factors that drove the recently noticed increased cross market linkages between stock and commodity markets for the time period spanning January 2000 to January 2011 by making use of correlation and VAR models. They discovered that since the year 2009 global commodity prices are exhibiting an increasing trend and also that their correlation with commodity prices has enhanced. They recognized markets by making use of historical decomposition VAR models. They provided quantitative facts that the commodity boom past 2009 was fuelled by i) the growing demand for physical commodities amidst global economic recovery ii) accommodative monetary conditions globally and that these results are in sharp contrast with the commodity boom that occurred prior to September 2008, which had led substantial capital inflows from other asset markets into commodity markets. Besides, they formed and presented quantitative evidence that any increase in cross market linkage between stock and commodity markets was a result of the markets increased co-movements owing to large variations in the global economy all through the financial crises over and above by the financialization of commodities which means that financial backers are increasingly indulging in commodities as a class of investment assets.

Bahattin Buyuusahin, Micheal S. Haigh and Michel A. Robe (2008) explored the relation linking commodity and equity markets. The researchers investigated Dow-Jones DJIA Index and S& P 500 Index as an alternative for equity and DOW- Jones DJIA

Commodity Index and S&P GSCI (Goldman Sachs Commodity Index) for commodities. They took into account three Sub-periods (1) June 1992 up to May 1997 (2) June 1997 up to May 2002 (3) June 2003 up to May 2008 and made use of descriptive statistics, Simple Correlations, Cointegration and Summary Statistics for analyzing data. The investigators provided evidence that challenged the notion that commodities these days move in sync with common traditional financial assets. Utilising cointegration and correlation techniques they found that the relationship between returns on investible commodities and the United States equity indices have not changed notably. They also found no proof of any secular raise in co-movement connecting the equity investments and returns on commodity during phases of extreme returns. Their findings are in keeping with the belief that commodities persist in providing benefits to equity backers in terms of portfolio range and diversification.

Anna Creti, Marc Joets and Valerie Mignon (2012) examined the relationships between stock and commodity markets and also analysed whether these associations evolve according to the given situation namely bearishness or bullishness in the stock markets. They employed DCC (Dynamic Conditional Correlation) GARCH approach initiated by Engle (2002) and the data included CRB (Commodity Research Bureau) Price Indexes and S&P 500 and considered commodities spanning various sectors like agriculture, energy, metals and food, for the time period from January 2001 up to November 2011. The results of this study showed that the correlations linking stock and commodity returns evolve over a period of time as to being highly volatile, predominantly since the financial crisis of 2007-08. The stock market fall has unfastened the linkages between both markets in the very short run, the highest level of correlations are detected during times of financial turmoil, thereby, exhibiting increased links between commodity and stock markets.

Hector O. Zapata, Joshua D. Detre and Tatsuga Hanabuchi (2012) studied the economic measurement of the purported strength of the cyclical relationships linking commodity and stock markets and also evaluated the role of publicly traded agribusiness companies and agricultural commodities in investment portfolios. The study period spanned from 1871 to 2010 and the data was collated from S&P 500 PPI (produced price index) taken for all commodities and some select components (farm, food, metals and fuel) were utilized to represent commodity and stock prices. The results of the study point out that a high negative correlation is present between commodity and stock prices. The recent price domination in agricultural commodities began in the year 2000, which is shored up by the empirical results of portfolio allocation analysis. For an investor averse to risk, irrespective of the analysis period, placing funds in agricultural indexes and/or agribusiness was a sound investment.

Menzie D. Chinn and Olivier Coibion (2013) scrutinized the predictive component of futures prices for a wide range of commodities that included agricultural commodities, energy, precious and base metals, for the time period from January 1990 to July 2012 by using techniques like basic regression, GARCH and ARCH models. They detected significant differences within and across commodity groups. Precious and base metals fell short of most tests of impartiality and were poor predictors of later price changes. In stark contrast, energy futures and to some extent, agricultural futures fared considerably better. They also documented extensive decline in the projecting content of commodity future prices, ever since the year 2000.

Anne Laure Deleatek and Claude Lopez (2012) examined the dependence configuration existing linking the returns of commodity and equity futures and its progression through the past 20 years and also investigated the existence of co-movement involving them for the

period spanning 1990 to 2012, by employing the GARCH model. They concluded that the relitionship between stock and commodity markets is symmetric, time varying and arises most of the time. They also recognized growing co-movement between equity markets and industrial metals as early as during the year 2003. This movement spreads across to all commodity classes and becomes explicitly stronger along with the global financial crisis induced fall in 2008.

Akash Dania (2011) examined the relationship between the commodity markets returns and equity markets focusing especially on agriculture produce, industrial metals and precious metals categories for the period from 1990 to 2008. The researcher presented a superior understanding of the linkage of the returns of equity market and the commodities returns. He used descriptive statistics & Vector Auto Regression models. The results imply equity market returns and commodity market returns have minimal or no noteworthy positive interdependence, thus signalling diversification gains from investing in commodities, which implies a portfolio including commodities is apt to dominate a portfolio devoid of commodity investments.

Samuel Roeca (2011) investigated the recent co-movements by probing GSCI commodities futures returns, S&P 500 Stock returns and their correlation vis-a-vis the business cycle for the time period from 1979 to 2010 by employing regression and correlation. The results of the research reveal that before the 2008-09 down turn, the average moving correlation connecting commodities futures returns and stock returns was neat to zero through each phase of the business cycle. However, during the latter half of the collapse, the correlation between commodities futures contracts and stock returns became high, thereby causing investors to query the hedging characteristics of their commodity investments.

Hossein Kazemi, Thomas Schneeweis and Richard Spurgin (2009) evaluated the theoretical aspects for the return and risk benefits of commodity investments and reviewed the performance of selected three commodity indices specifically the S&P GSCI Commodity Index (SPGSCI), The Dow Jones AIG Commodity Index (DJAIG) and Bache Commodity Index (BCI) and the movements of these commodity indices when compared with alternative and traditional investments for the time period 1991 to 2008. The study utilized the correlation, annual return, the Sharpe ratio and standard deviation, with these three commodity indices. The study demonstrated that direct commodity investments in investible indices may provide significant portfolio diversification gains. By adding a commodity element to a diversified collection of alternative assets, bonds and stocks have exhibited the improved risk adjusted performance.

Paul Cashin, C. John, M. C. Dermolt and Alasdair Scott (1999) inspected the genuineness of the belief of co-movements of unconnected commodity prices. The study assessed the co-movement of Concordance economic time series. It measure the level to which the cycles of two series may be synchronized, which in turn implies that the proportion of time which the prices of commodities could be in the same slump or boom period. The time period of the study spans from 1980 to 1997, in which seven apparently unrelated commodities namely copper, wheat, cotton, oil, gold, cocoa and lumber were analyzed by correlation and concordance analysis. The study concluded that the impression that prices of dissimilar commodities move mutually is a myth. However, there is strong proof of co-movement within the prices of groups of seemingly related commodities.

Takeshi Inoque and Shigeyuki Hamori (2012) appraised the market efficiency of Indian commodity futures markets which has been growing incredibly during the period covering 2006 to 2012. The data used for this study was from Future Index and MCX Spot Index by

employing FMOLS and DOLS methods. The results of this study signify that a co-integration relationship is established between spot and future indices and commodity futures market seems to be efficient throughout the period post-July 2009.

Vijay Kumar Varadi (2012) endeavoured to investigate for the facts and impact of conjecture on unpredictability of commodity prices within Indian commodity markets covering the period from 2006 to 2010. The study scrutinized fortnightly data cumulated as monthly series for NCDEX and MCX by using VAR Granger causality and correlation tests. The results show that conjecture has played a key role in the commodity price mirage in India, during the global crisis.

Thai-Ha Le and Youngho Chang (2011) investigated the association between the prices of two premeditated commodities namely oil and gold. The study period was from 1986 up to 2011. VAR and Granger causality test were used to examine the data. The study inferred that there exists a long-term relationship between the prices of gold and oil. The study concluded that the oil prices could be utilized to forecast the gold price.

Frank Asche & Atle G. Guttormsen (2002) observed the relationship between future & spot oil prices. The time period of the study spanned from 1981up to 2001. The statistical tools utilized to study the data were Vector Error Correction models and Johansen test of Co-integration analysis. The conclusions of the study signify that future prices guide spot prices and futures contracts having longer expiration time leads contracts with shorter expiration time.

Jorg Mayer (2009) examined two types of investors namely money managers and index traders. He emphasized the dissimilarities in their positions by taking price impacts and motivation for the time period from 2006 to 2009. Granger-Causality tests and Regression Analysis were used for this study. The results of regression analysis show that (a) An Index traders position are particularly influenced by roll returns, whereas, money managers accentuate spot returns.(b) Money managers shift from emphasizing diversification to more speculative strategies by taking up commodity positions that are more positively rather than negatively linked to developments in equity markets. Granger causality tests showed that these differences convert into diverse price impacts (a) index trader positions encompass a causal prices impact mainly for agriculture commodities and (b) money managers encompass a causal impact through sharp increases in the prices, for various non-agricultural commodities.

Ke Tang and Wei Xiong (2012) examined the concurrent brisk development of index outlays in commodity markets and found that prices of non-energy commodities had become progressively more correlated to oil prices. The period taken for was from 2nd June 1998 up to 31st August 2008. The investigators used regression and correlation for analyzing the data. The study inferred that the progression of financialization amongst commodity markets has resulted in commodity prices becoming progressively correlated with each other.

Bahattin Buyuksahin and Michel A. Robe (2011) studied the co-movements between equity markets and commodity rather than the relationships between different commodity futures markets from 1991 up to 2010. The data used was S&P GSCI for commodities and S&P 500 index for equities. The statistical tools utilised were dynamic conditional correlation (DCC) methodology of Engle (2002), descriptive statistics, regression and

Augmented Dickey Fuller (ADF) tests. They established correlations between the returns on equity indices and investable commodities increase due to greater participation by speculators in general and especially due to hedge funds.

C. Nangolo and C. Musingwini (2011) scrutinized the degree to which the mineral commodity spot price, long term price and forward price, manipulates the mining stock prices. Their intention was to offer investors in mining stocks a better understanding of how variations of commodity prices in due course impacts the prices of the mining stocks, which they hold on to or intend to buy or sell. The period of study was from 2004 up to 2010. Pearson correlation statistical technique was utilised for the purpose of this study. The study concluded that mining stock prices were correlated to mineral commodity prices, however, forward and spot prices exhibited stronger correlation when compared to long term prices. The results also confirmed that direct commodity investment presents return opportunities and risk, which are not available on investments in commodity company's equity. A review of commodity performances over the six year period of this study revealed the continued gains of endowable commodity indices to augment the risk regulated performance of traditional assets.

Jason Laws and John Thompson (2007) studied the introduction of commodities into futures portfolios comprising of stock index futures increases the average portfolio returns. The period of this study was from 1994 up to 2007. Correlation and descriptive statistics were used to compare portfolios having and not having commodities in them, the study showed that inclusion of commodities led to an increase in returns without a consequent rise in risk.

T. Viswanathan and G. Sridharan (2014) inspected the causal relationship linking the price of Pepper in the futures and spot markets. The daily closing futures and spot prices of Pepper in National Commodities and Derivatives Exchange for the time period from financial year 2005-06 to 2012-13 were used as input for this study. The relationships connecting the two series were analyzed by using Granger Causality test. Jarque Bera test and descriptive statistics were also applied to study the distribution character of the time series data of futures and spot prices of Pepper. Correlogram analysis was used to test the existence of auto correlation within the series. The Augmented Dickey Fuller test (ADF) showed that the data series of futures and spot prices of Pepper are still at first order level. Granger Causality test was applied to inspect the relationship between future and spot prices of Pepper. The test results point to a bilateral causality linking the price of Pepper in the futures and spot prices.

Nobuyoshi Yamori (2011) examined the relationship between equity markets and commodity markets by utilising Japanese daily returns data throughout the period of the global financial crisis and found out that while the correlation linking commodity markets and equity markets used to be negative or nearly zero before 2006, it had increased appreciably post-the global financial disaster in the autumn of 2008. This situation led to the commodity market losing its character as a reliable alternative asset. The study detailed the recent alterations regarding participants in the commodity markets. The study inferred that in addition to conventional participants like hedgers, who procure commodities (e.g. oil and corn) to manufacture final goods and services, monetary investors including financial institutions, pension funds and hedge funds have keenly traded in commodities.

Nissar A. Barua and Devajit Mahanta (2012) observed that ever since its revival post-1991, Indian commodity derivatives trading had experienced unpredictable growth, both in terms of value and volumes over the years, across the entire spectrum of contracts that were in action for most major agricultural commodities, energy and metal. However, the derivatives trade in agricultural commodities was faced by a huge crisis when the Government imposed in 2007-08 a provisional ban on futures trades of select items as a component of its inflation-control measures. But in view of the inconsequential volumes of trades in commodity futures of all the newly banned commodities it was often argued that futures trading could not and would not directly impact the prices of these commodities. However, tests on current data revealed that the outcome of futures prices on the spot prices for diverse commodities varies which in turn implies that there is no standardized impact of commodity derivatives trades on spot prices of the extensive assortment of commodities that were traded. This tangible unfolding of events supports the view that inflationary pressures spring from a number of diverse factors, which include supply side constraints, the universal rise in prices of oil and food, the diversion of land for production of bio-fuel, wobbly monetary policy in up-and-coming economies and the embracing of an extensionary fiscal policy. The study inferred that the policy of all-embracing restriction on derivative trades in agricultural commodities appeared to be inequitable, unjustifiable and counter-productive.

Sagar Suresh Dhole (2014) sought to explain the growth, rationale and legality of Indian commodity future trades markets, along with the characteristic structure of commodity futures markets. He catalogued in detail the narration of Indian commodity derivatives markets. The FMC was created in the year 1953 under the stipulations of the Forward Contracts (Regulation) Act, 1952. The Government reckoned that derivative markets amplified speculation which in turn led to enhanced costs and created price instabilities.

However, by the mid 1960s, the Government took a radical step by disallowing derivatives trading. The commodity derivative market stayed virtually absent during the following four decades and it re-emerged only in the early 2000s. The market has since progressed massively in terms of transparency, technology and the trading activity. Fascinatingly, this has emerged only after the prohibition by Government was eradicated from a several commodities and the market forces were allowed to act.

Shree Bhagwat and Angad Singh Maravi (2015) examined the performance of FMC and its regulatory efforts in the Indian commodity derivatives market. The outcomes show key developments of FMC. Derivatives and commodity futures play a fundamental role in the process of price risk management, mainly in the agriculture sector. Since commodity futures trading were allowed in 2003, the Indian commodity derivatives market experienced an increase in the number of commodity exchanges besides also an increase in the number of commodities traded as well as in terms of value and volume of commodities derivatives traded.

Dharamveer and Barinder Singh (2011) described in great detail about the growth of traded contracts for various commodities, besides the connection between commodity contracts and other economic factors. The research concluded that the expansion of commodity markets was remarkable during last decade. Prices of almost all commodities increased due to brisk increase in orders for commodities and worldwide commodity markets are bigger when compared to the stock markets. It represents the market where a wide variety of products, viz., crude oil, precious metals, energy, base metals and soft commodities viz. coffee, palm oil etc. are being traded. They advocated that a liquid, active and vibrant commodity market be developed. This in turn would assist investor's hedge their inherent commodity risks, exploit arbitrage opportunities in commodities and take

speculative positions in the market. The value of traded contracts in the commodity market symbolizes the people's awareness with respect to the market and the demand for trading. The inverse relationship of commodity markets by way of the stock market illustrates the alternative available for investors at any time they expect a bearish trend.

V.P. Saranya (2015) spotlighted on the study of the futures market for chosen non-agricultural commodities. The investigator examined whether futures markets indicate the spot market developments or vice-versa and also scrutinized the unpredictability in the futures prices. The study has utilised secondary data concerned with futures prices and spot prices of eleven selected non-agricultural commodities which include of precious metals and energy. Daily closing futures and spot prices, open interest positions and trading volume were collected from the website of one of the piloting commodity exchanges in India. The study worked out the returns in the futures and spot market for the time period from 2008 to 2014. The study has used econometric tools like unit root test to examine the stationarity and used Granger Causality test to determine the lead-lag relationship connecting the futures and spot returns. GARCH model was used to study the volatility in the futures and spot returns. The study inferred that there was a unidirectional causality in the selected commodities (like Tin and Silver) which signifies that spot returns lead to futures returns. They found bi-directional causality in the case of copper, wherein the futures returns lead to spot returns and vice versa. For some other commodities like copper, nickel, aluminum, lead, zinc, silver and gold, the trade volume coefficient was positive and open interest was negative. The study confirmed the presence of volatility in the selected non-agricultural commodities and that unpredictability is commonplace in both futures and spot markets.

2.2 Research Gap:

Most of the studies conducted by researchers on commodity derivatives markets have been mostly conceptual in nature. Majority of the studies have considered one commodity index and very few agricultural commodities. There has not been in depth study on commodity derivatives market in India in a detailed manner, especially at individual commodity level wherein all commodities representing agricultural, bullion, energy and metals have been considered at a time along with all spot and future commodity indices. Most of the studies have also remained inconclusive about the linkages among the commodity markets and the equity market in India which required further detailed analysis in the form of present study.

The empirical research on the role of price discovery and volatility spillover is limited especially with regards to the level and direction of informational spillover in commodity market. Given the recent upheavals in the commodity derivatives market in India, there is an urgent need to find out whether the spot or futures market plays decisive role in the price discovery process and whether the volatility spillover is unidirectional or bidirectional. In the present context, the current study attempts to create and add value to the existing literature in the area of commodity derivatives market and its impact on equity market in India.

CHAPTER 3

RESEARCH METHODOLOGY

AND

DESIGN

3.1. Introduction:

In India, the commodity derivatives market plays a pivotal role in futures trading, risk sharing and information pooling, thereby, drawing extensive attention towards itself. The trading in commodity derivatives accomplishes two key functions, in particular, price risk management and price discovery, with reference to any given commodity. The commodity derivatives market offers an effective mechanism for price risk management that covers all stakeholders who are participants in the commodity trading process. The stakeholders range from the producers, traders and processors up to the exporters and importers and the consumers of a commodity. The commodity derivatives market presents trading, hedging and arbitrage opportunities to the market players. It is also useful to all sectors of the economy, as it assures stability in supply and demand positions and also eliminates the perils of price uncertainty, promotes competition and plays the role of a price guide, to the farmer and other stakeholders in the economy.

3.2 Statement of the Research Problem:

In recent years investing in commodities has undergone a sea change and has witnessed sturdy growth with many innovations. The market has made enormous evolvement in terms of transparency, technology, and trading activity. Since the inception of modern electronic trading platform, combined with establishment of national commodity exchanges, India has become one of the fastest growing commodity derivatives market in the world.

With the tremendous growth achieved in the commodity derivatives market in India, there is a need to evaluate the present status, trading patterns and trends in the commodity derivatives market. It needs to investigated whether the spot or the futures markets play a major role in the price discovery process. There is also need to know whether there is unidirectional flow of information from the futures market to the spot market, or spot

market to the futures market or a bidirectional flow of information between these markets. This helps in understanding the extent of relationship between the futures and spot markets and the speed of adjustments between the markets. The important function of commodity derivatives markets is price discovery. In order to perform the price discovery function effectively, the futures markets need to incorporate new information more quickly than the spot markets.

In the light of the growth in commodity derivatives market and having a developed equity market in India there is a need to examine the linkages between the commodity derivatives market and equity market in India. There is also a need to know whether the volatility spillover is unidirectional or bidirectional between the commodity market and equity market in India.

In view of the above, the researcher intends to state the summarized research problems as follows:

1. What is the position of the commodities derivatives market in India?
2. What are the trading patterns and trends in the commodity derivatives market in India?
3. What is the process of discovery of prices and volatility spillover in the Indian commodity derivatives market?
4. What is the process of price discovery and volatility spillover in select commodities on select Indian commodity derivative exchanges?
5. What are the linkages between commodities market and equity market in India?

3.3 Significance of the Study:

Despite the tremendous growth in the commodity derivative market in India, there has not been in comprehensive study on the commodity market in India. The study attempts to make a detailed study on the commodity derivatives market by studying the present status, trading patterns and trends, spot commodity market, commodity derivatives market, all individual commodities being traded in the commodity derivatives market with regard to price discovery and volatility spillover. The study evaluates the linkages between the commodity markets and equity market in India.

The study will provide direction whether commodity derivatives markets provide price risk management and price discovery benefits to the participants. The study attempts to investigate whether there are linkages between the commodity derivatives market and equity markets in India and its opportunities to investors. The study will benefit the investors if there exists an inverse relationship between the equity and the commodity derivative markets. The investors can benefit by diversifying their investments and minimizing the market risk.

3.4 Objectives of the Study:

This research intends to investigate the following:

1. To study the present status, trading patterns and trends in the commodity derivative markets in India.
2. To evaluate the price discovery and volatility spillover among the spot and future commodity markets in India.

3. To investigate the price discovery and volatility spillover in individual commodity spot and future prices on select commodities exchanges in India.

4. To analyze the market linkages and volatility spillover among the commodity derivatives market and equity market in India.

3.5 Scope of the Study:

The study mainly focuses on Indian commodity market and its impact on equity markets in India. The study covers the price discovery and volatility spillover in the spot and futures commodity market in India. The MCX commodity spot and futures indices are considered for the purpose of study of the spot and futures commodity markets representing MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

The study also analyses the individual commodities price discovery and volatility spillover in the Indian commodity market. The individual commodities considered for the study represent commodities traded at MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector. The individual agricultural commodities are considered from NCDEX as it has the major market share in agricultural trading, whereas individual bullion, energy and metal commodities are considered from MCX as it has the major market share in the non agricultural commodities.

The linkages among the commodity markets and equity market in India is analysed by considering the MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL commodity markets and the NSE NIFTY and BSE SENSEX market.

3.6 Hypotheses of the Study:

To test the above stated objectives, following null hypotheses are formulated:

Price discovery and volatility spillover in the spot and futures commodity markets of MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL

Hypothesis 1

H_0: Future and Spot prices of the commodity markets, viz., MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL consist of Unit Root (Non-Stationary condition).

Hypothesis 2

H_0: There is no long-run relationship between Spot and Futures prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively.

Hypothesis 3

H_0: Spot prices do not lead to futures prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL in the long-run

Hypothesis 4

H_0: Futures prices do not lead to spot prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL in the long-run.

Hypothesis 5

H_0: Spot prices do not lead to futures prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL in the short-run.

Hypothesis 6

H_0: Futures prices do not lead to spot prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL in the short-run.

Hypothesis 7

H_0: There are no ARCH effects on the spot and future prices in commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL

Hypothesis 8

H_0: Volatility of Spot prices does not spillover to futures prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

Hypothesis 9

H_0: Volatility of futures prices does not spillover to spot prices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

Price discovery and volatility spillover in the spot and futures prices of individual commodities of MCX and NCDEX

Hypothesis 10

H_0: Spot and Futures prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector consist of Unit Root (Non-Stationary condition).

Hypothesis 11

H_0: There is no long-run relationship between Spot and Futures prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector, respectively.

Hypothesis 12

H_0: Spot prices do not lead to futures prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector in the long-run.

Hypothesis 13

H_0: Futures prices do not lead to spot prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector in the long-run.

Hypothesis 14

H_0: Spot prices do not lead to futures prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector in the short-run.

Hypothesis 15

H_0: Futures prices do not lead to spot prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector in the short-run.

Hypothesis 16

H_0: There are no ARCH effects on the spot and future prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector.

Hypothesis 17

H_0: Volatility of Spot prices does not spillover to futures prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector.

Hypothesis 18

H_0: Volatility of futures prices does not spillover to spot prices of individual commodities of MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector.

Linkages and volatility spillover among MCX Commodity Markets and NSE NIFTY Market

Hypothesis 19

H_0: MCX and NSE-NIFTY prices consist of Unit Root (Non-Stationary condition).

Hypothesis 20

H_0: There is no long-run relationship between MCX and NSE-NIFTY prices.

Hypothesis 21

H_0: MCX prices do not lead to NSE-NIFTY prices in the long-run.

Hypothesis 22

H_0: NSE-NIFTY prices do not lead to MCX prices in the long-run.

Hypothesis 23

H_0: MCX prices do not lead to NSE-NIFTY prices in the short-run.

Hypothesis 24

H_0: NSE-NIFTY prices do not lead to MCX prices in the short-run.

Hypothesis 25

H_0: There are no ARCH effects on the MCX and NSE-NIFTY prices.

Hypothesis 26

H_0: Volatility of MCX prices does not spillover to NSE-NIFTY prices.

Hypothesis 27

H_0: Volatility of NSE-NIFTY prices does not spillover to MCX prices.

Linkages and volatility spillover among MCX Commodity Markets and BSE SENSEX Market

Hypothesis 28

H_0: MCX and BSE-SENSEX prices consist of Unit Root (Non-Stationary condition).

Hypothesis 29

H_0: There is no long-run relationship between MCX and BSE-SENSEX prices.

Hypothesis 30

H_0: MCX prices do not lead to BSE-SENSEX prices in the long-run.

Hypothesis 31

H_0: BSE-SENSEX prices do not lead to MCX prices in the long-run.

Hypothesis 32

H_0: MCX prices do not lead to BSE-SENSEX prices in the short-run.

Hypothesis 33

H_0: BSE-SENSEX prices do not lead to MCX prices in the short-run.

Hypothesis 34

H_0: There are no ARCH effects on the MCX and BSE-SENSEX prices.

Hypothesis 35

H_0: Volatility of MCX prices does not spillover to BSE-SENSEX prices.

Hypothesis 36

H_0: Volatility of BSE-SENSEX prices does not spillover to MCX prices.

3.7 Research Methodology:

Research methodology is divided into four sections. Section I is on Data Sources, Section II is on Period of the Study, Section III is on Sample Size and Section IV is on Statistical tools, techniques and models used to carry out the study.

3.7.1 Data Sources and Data Collection:

The data required for the study is collected from secondary sources as there is no scope for primary data in the study. The secondary sources include books, journals, handbooks, newspapers, circulars, bulletins, working papers, reports, MCX website, NCDEX website, FMC website, SEBI website, NSE website and BSE website.

3.7.2 Period of the Study:

The time frame chosen for the empirical study on commodity derivatives in India and its impact on equity markets covers the time period from 15 January 2004 and going up to 31 March 2015. However among the commodities studied the time period studied is not identical in the sense it varies significantly on account of some commodities being

introduced for trading on the exchange at a later date and some commodities were banned from trading for a certain period by the Forwards Market Commission.

3.7.3 Sample Size:

The study has considered four commodity spot indices, four commodity futures indices, two equity indices, forty five individual commodities (25 agricultural, 3 bullion, 7 energy and 10 metal) spot prices and forty five individual commodities (25 agricultural, 3 bullion, 7 energy and 10 metal) future prices. The study covers the closing prices of MCX spot market namely MCXSCOMDEX, MCXSAGRI, MCXSENERGY and MCXSMETAL and corresponding underlying future market namely MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL. The individual agricultural commodities are considered from NCDEX as it has the major market share in agricultural trading, whereas individual bullion, energy and metal commodities are considered from MCX as it has the major market share in the non agricultural commodities. The NSE NIFTY and BSE SENSEX are considered for the equity market. The closing daily prices have been obtained from NCDEX, MCX, NSE and BSE websites. The list of select commodity indices, equity indices and individual commodities are given below:

Table 3.1: List of Commodity Indices, Equity Indices and Individual Commodities

Sr. No.	Data Variable	Commodity/ Index	Exchange	Spot/ Future Price	Data Period		Number of Observations
					From	To	
1	MCXSCOMDEX	Commodity Index	MCX	Spot Price	07-06-2005	3/31/2015	2401
2	MCXSMETAL	Commodity Index	MCX	Spot Price	07-06-2005	3/31/2015	2401
3	MCXSENERGY	Commodity Index	MCX	Spot Price	07-06-2005	3/31/2015	2401
4	MCXSAGRI	Commodity	MCX	Spot Price	07-06-	3/31/2015	2401

		Index			2005		
5	MCXCOMDEX	Commodity Index	MCX	Future Price	07-06-2005	3/31/2015	2401
6	MCXMETAL	Commodity Index	MCX	Future Price	07-06-2005	3/31/2015	2401
7	MCXENERGY	Commodity Index	MCX	Future Price	07-06-2005	3/31/2015	2401
8	MCXAGRI	Commodity Index	MCX	Future Price	07-06-2005	3/31/2015	2401
9	NIFTY	Equity Index	NSE	Spot Price	07-06-2005	3/31/2015	2401
10	SENSEX	Equity Index	BSE	Spot Price	07-06-2005	3/31/2015	2401
11	Barley	Agricultural Commodity	NCDEX	Spot Price	12/29/2006	3/31/2015	2050
12	Castor Seeds	Agricultural Commodity	NCDEX	Spot Price	8/25/2005	3/31/2015	1334
13	Chana	Agricultural Commodity	NCDEX	Spot Price	1/1/2005	3/31/2015	2539
14	Chilli	Agricultural Commodity	NCDEX	Spot Price	11/10/2005	3/31/2015	1817
15	Corriender	Agricultural Commodity	NCDEX	Spot Price	8/11/2008	3/31/2015	1738
16	Cotton Seed Oil Cake	Agricultural Commodity	NCDEX	Spot Price	12/10/2005	3/31/2015	2589
17	Cotton	Agricultural Commodity	NCDEX	Spot Price	1/1/2009	3/31/2015	624
18	Crude Palm Oil	Agricultural Commodity	NCDEX	Spot Price	1/15/2004	3/31/2015	3166
19	Gur Gum	Agricultural Commodity	NCDEX	Spot Price	7/27/2004	3/27/2012	2303
20	Gur Seed	Agricultural Commodity	NCDEX	Spot Price	4/12/2004	3/27/2012	2374
21	Gur	Agricultural Commodity	NCDEX	Spot Price	12/10/2007	3/31/2015	2025
22	Jeera	Agricultural Commodity	NCDEX	Spot Price	2/3/2005	3/31/2015	2802
23	Kapas	Agricultural Commodity	NCDEX	Spot Price	3/30/2007	3/31/2015	546
24	Maize	Agricultural Commodity	NCDEX	Spot Price	2/7/2005	7/22/2013	2277
25	Menta Oil	Agricultural Commodity	NCDEX	Spot Price	8/29/2005	4/29/2011	1527
26	Mustard Seed	Agricultural Commodity	NCDEX	Spot Price	11/10/2010	3/31/2015	1202

27	Peas	Agricultural Commodity	NCDEX	Spot Price	6/1/2005	12/18/2009	1288
28	Pepper	Agricultural Commodity	NCDEX	Spot Price	1/1/2005	5/20/2003	2422
29	Potato	Agricultural Commodity	NCDEX	Spot Price	3/9/2009	9/30/2013	942
30	Rubber	Agricultural Commodity	NCDEX	Spot Price	11/29/2007	4/17/2014	1691
31	Soya Oil	Agricultural Commodity	NCDEX	Spot Price	11/3/2005	3/31/2015	2540
32	Soyabean	Agricultural Commodity	NCDEX	Spot Price	1/15/2004	3/31/2015	3189
33	Sugar	Agricultural Commodity	NCDEX	Spot Price	1/1/2008	9/19/2014	1496
34	Turmeric	Agricultural Commodity	NCDEX	Spot Price	1/1/2005	3/31/2015	2208
35	Wheat	Agricultural Commodity	NCDEX	Spot Price	1/2/2006	3/31/2015	2107
36	Gold	Bullion Commodity	MCX	Spot Price	1/31/2007	3/31/2015	2256
37	Silver	Bullion Commodity	MCX	Spot Price	6/20/2008	3/31/2012	1074
38	Platinium	Bullion Commodity	MCX	Spot Price	1/1/2007	3/31/2015	2279
39	ATF	Energy Commodity	MCX	Spot Price	1/1/2009	12/6/2012	987
40	Brent Crude Oil	Energy Commodity	MCX	Spot Price	1/2/2007	3/31/2015	1845
41	Crude Oil	Energy Commodity	MCX	Spot Price	12/26/2006	3/31/2015	2262
42	Furnace Oil	Energy Commodity	MCX	Spot Price	1/1/2007	12/6/2009	671
43	Gasoline	Energy Commodity	MCX	Spot Price	1/7/2009	12/6/2012	859
44	Heating Oil	Energy Commodity	MCX	Spot Price	1/5/2009	12/6/2012	981
45	Natural Gas	Energy Commodity	MCX	Spot Price	12/23/2006	3/31/2015	2272
46	Aluminium	Metal Commodity	MCX	Spot Price	2/1/2007	3/31/2015	2317
47	Copper	Metal Commodity	MCX	Spot Price	12/23/2006	3/31/2015	2275
48	Iron Ore	Metal Commodity	MCX	Spot Price	1/29/2011	12/31/2012	551
49	Lead	Metal Commodity	MCX	Spot Price	2/1/2007	3/31/2015	2281
50	Nickel	Metal Commodity	MCX	Spot Price	2/8/2007	3/31/2015	2536

51	Sponge Iron	Metal Commodity	MCX	Spot Price	1/16/2007	6/15/2009	616
52	Steel Flat	Metal Commodity	MCX	Spot Price	2/16/2007	6/15/2009	602
53	Thermal Coal	Metal Commodity	MCX	Spot Price	1/9/2009	12/6/2012	839
54	Tin	Metal Commodity	MCX	Spot Price	1/1/2007	6/29/2012	1524
55	Zinc	Metal Commodity	MCX	Spot Price	1/1/2007	3/31/2015	2528
56	Barley	Agricultural Commodity	NCDEX	Future Price	12/29/2006	3/31/2015	2050
57	Castor Seeds	Agricultural Commodity	NCDEX	Future Price	8/25/2005	3/31/2015	1334
58	Chana	Agricultural Commodity	NCDEX	Future Price	1/1/2005	3/31/2015	2539
59	Chilli	Agricultural Commodity	NCDEX	Future Price	11/10/2005	3/31/2015	1817
60	Corriender	Agricultural Commodity	NCDEX	Future Price	8/11/2008	3/31/2015	1738
61	Cotton Seed Oil Cake	Agricultural Commodity	NCDEX	Future Price	12/10/2005	3/31/2015	2589
62	Cotton	Agricultural Commodity	NCDEX	Future Price	1/1/2009	3/31/2015	624
63	Crude Palm Oil	Agricultural Commodity	NCDEX	Future Price	1/15/2004	3/31/2015	3166
64	Gur Gum	Agricultural Commodity	NCDEX	Future Price	7/27/2004	3/27/2012	2303
65	Gur Seed	Agricultural Commodity	NCDEX	Future Price	4/12/2004	3/27/2012	2374
66	Gur	Agricultural Commodity	NCDEX	Future Price	12/10/2007	3/31/2015	2025
67	Jeera	Agricultural Commodity	NCDEX	Future Price	2/3/2005	3/31/2015	2802
68	Kapas	Agricultural Commodity	NCDEX	Future Price	3/30/2007	3/31/2015	546
69	Maize	Agricultural Commodity	NCDEX	Future Price	2/7/2005	7/22/2013	2277
70	Menta Oil	Agricultural Commodity	NCDEX	Future Price	8/29/2005	4/29/2011	1527
71	Mustard Seed	Agricultural Commodity	NCDEX	Future Price	11/10/2010	3/31/2015	1202
72	Peas	Agricultural Commodity	NCDEX	Future Price	6/1/2005	12/18/2009	1288
73	Pepper	Agricultural Commodity	NCDEX	Future Price	1/1/2005	5/20/2003	2422
74	Potato	Agricultural Commodity	NCDEX	Future Price	3/9/2009	9/30/2013	942

75	Rubber	Agricultural Commodity	NCDEX	Future Price	11/29/2007	4/17/2014	1691
76	Soya Oil	Agricultural Commodity	NCDEX	Future Price	11/3/2005	3/31/2015	2540
77	Soyabean	Agricultural Commodity	NCDEX	Future Price	1/15/2004	3/31/2015	3189
78	Sugar	Agricultural Commodity	NCDEX	Future Price	1/1/2008	9/19/2014	1496
79	Turmeric	Agricultural Commodity	NCDEX	Future Price	1/1/2005	3/31/2015	2208
80	Wheat	Agricultural Commodity	NCDEX	Future Price	1/2/2006	3/31/2015	2107
81	Gold	Bullion Commodity	MCX	Future Price	1/31/2007	3/31/2015	2256
82	Silver	Bullion Commodity	MCX	Future Price	6/20/2008	3/31/2012	1074
83	Platinium	Bullion Commodity	MCX	Future Price	1/1/2007	3/31/2015	2279
84	ATF	Energy Commodity	MCX	Future Price	1/1/2009	12/6/2012	987
85	Brent Crude Oil	Energy Commodity	MCX	Future Price	1/2/2007	3/31/2015	1845
86	Crude Oil	Energy Commodity	MCX	Future Price	12/26/2006	3/31/2015	2262
87	Furnace Oil	Energy Commodity	MCX	Future Price	1/1/2007	12/6/2009	671
88	Gasoline	Energy Commodity	MCX	Future Price	1/7/2009	12/6/2012	859
89	Heating Oil	Energy Commodity	MCX	Future Price	1/5/2009	12/6/2012	981
90	Natural Gas	Energy Commodity	MCX	Future Price	12/23/2006	3/31/2015	2272
91	Aluminium	Metal Commodity	MCX	Future Price	2/1/2007	3/31/2015	2317
92	Copper	Metal Commodity	MCX	Future Price	12/23/2006	3/31/2015	2275
93	Iron Ore	Metal Commodity	MCX	Future Price	1/29/2011	12/31/2012	551
94	Lead	Metal Commodity	MCX	Future Price	2/1/2007	3/31/2015	2281
95	Nickel	Metal Commodity	MCX	Future Price	2/8/2007	3/31/2015	2536
96	Sponge Iron	Metal Commodity	MCX	Future Price	1/16/2007	6/15/2009	616
97	Steel Flat	Metal Commodity	MCX	Future Price	2/16/2007	6/15/2009	602
98	Thermal Coal	Metal Commodity	MCX	Future Price	1/9/2009	12/6/2012	839

99	Tin	Metal Commodity	MCX	Future Price	1/1/2007	6/29/2012	1524
100	Zinc	Metal Commodity	MCX	Future Price	1/1/2007	3/31/2015	2528

3.7.4 Statistical Techniques / Models used in the study:

1. Descriptive Statistics:

Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data.

Descriptive statistics are simply describing what is or what the data shows. Descriptive Statistics are used to present quantitative descriptions in a manageable form. Descriptive statistics help us to simplify large amounts of data in a sensible way. Each descriptive statistic reduces lots of data into a simpler summary.

Thus descriptive statistics tries to capture a large set of observations and gives us some idea about the data series. The measures of central tendency like mean, median, mode all come under this category, as do data distributions like normal distribution and corresponding standard deviations.

2. Trend Analysis:

Trend analysis is a technique for extracting an underlying pattern of behaviour in a time series which would otherwise be partly or nearly completely hidden by noise. Many a times the series contain trends, i.e. they are non-stationary. Trends may be linear, or have some more complex form, such as polynomial or logistic. Whatever the form of the trend it is usually preferable to remove and/or specify the trend explicitly prior to further analysis and

modelling. There are several ways in which this may be carried out. The first step is usually to examine the graph of the time series visually, to see if any trend-line behaviour can be observed. It may be that a series has no observable trend, has a trend across its range, or exhibits a trend in part of its range. Data can also be represented in the form of graphs or histograms to better understand.

3. Unit root test:

The series which are non stationary could lead to spurious results. The Augmented Dickey-Fuller test has been used to check the presence of a unit root in the series respectively. The Augmented Dickey Fuller test is conducted by augmenting the lagged values of the dependent variable in the series:

$$\Delta Yt = \beta 1 + \beta 2t + \delta Yt - 1 + \sum_{i=1}^{m} \alpha i \, \Delta Yt - 1 + \varepsilon t$$

Where εt is a pure white noise error term. The null hypothesis is δ=0, where $\delta = (p - 1)$ and the alternate hypothesis is $\delta < 0 \; (or \; p < 1)$. The acceptance of the null hypothesis signifies the presence of a unit root in the series, whereas the alternate hypothesis proves stationarity of the series (Singh & Kaur, 2014). On a somewhat similar note to ADF test, the Philips-Perron test accounts for stationarity of the data, whereby the null hypothesis is regarded as the existence of a unit root. The Philips-Perron test does not include lagged values of the first differences instead uses a long run variance estimation approach.

4. Johansen Cointegration Test:

Following Singh and Singh (2016), the present study employs Johansen Cointegration approach to account for long run co-movement and causal linkages among the variables in a multivariate framework. The Johansen method is a maximum likelihood approach based on two likelihood test statistics. Under the Trace test, the null hypothesis is that there is no

cointegrating vector (h_0: r = 0), whereas the alternative hypothesis of cointegration is n cointegrating vectors (h_1: r > 0). The Maximum Eigenvalue test, tests the null hypothesis of the numerical of cointegrating vectors is equivalent to r, and at the same time the alternative hypothesis tries to test the numerical of cointegrating vectors as r + 1.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda_i}\right)$$

$$\lambda_{max}(r, r + 1) = -T\, ln\left(1 - \hat{\lambda}_{r+1}\right)$$

Where r = number of cointegrating vectors and $\hat{\lambda_i}$ is the estimated eigenvalue from the $\alpha\beta'$ matrices, T is the number of usable observations. The Johansen test of cointegration requires that the lag lengths should be appropriate and consequently, the present study uses Akaike's Information Criterion values (AIC) to ascertain the lag lengths by employing VAR models at level across different time frames.

5. VECM Model:

The Johansen method finds out the cointegrating vectors, which are further appended into VAR models imposing certain restrictions known as VECM approach. The VECM model analyzes both short run as well as long run equilibrium relationships among the variables undertaken. The existence of a cointegrating vector exhibits the existence of a long run equilibrium relationship among the markets. The VECM equation is defined as follows:

$$\Delta x_t = \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \alpha\beta' u_{t-1} + \varepsilon_t$$

Where x_t is a non stationary series in its first differentiation (commodity indices), π_i is a matrix of coefficients, α is the speed of adjustment parameter, p is the lag order of the first differenced series, β' is cointegrating vector, u is the lagged error correction term and ε_t is the residual term. Under VECM, an endogenous variable is a function of its own lagged

values as well as lagged values of other variables. Apart from this, the error correction terms are also factored into the equations to ascertain disequilibrium adjustments.

6. GARCH Model:

The plain vanilla GARCH (1,1) model ascertains time-varying variance, however, it cannot ascertain the specific impact of a negative shock on the volatility, due to the assumption of the symmetric impact of a positive and a negative shock (Bollerslev, 1986). The residuals derived from the 'mean' equation are further modelled to account for conditional variance (Singh & Kaur, 2016).

Variance equation:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

Where σ_t^2 is the conditional variance, u_{t-1}^2 is lagged error term, σ_{t-1}^2 is lagged conditional variance. The lagged values of conditional variance in the variance equation show persistency level of the volatility and the error terms captures news impact on the volatility. The GARCH (1,1) model shall be stationary when $\alpha_1 + \beta_1$ is less than unity. Another important model is EGARCH model which also accounts for 'leverage effect'. The model has been developed by Nelson (1991). The term 'leverage effect' relates to a situation when falling returns have an increasing impact on the conditional variance.

Variance equation:

$$log h_t = \alpha_0 + \alpha_1 \left(\frac{|\varepsilon_{t-1}|}{h_{t-1}} - \sqrt{\frac{2}{\pi}} \right) + \delta \frac{\varepsilon_{t-1}}{h_{t-1}} + \beta_1 h_{t-1}$$

Where δ is the asymmetry coefficient capturing asymmetric response of conditional variance toward negative and positive shocks. The leverage effect will be there when $\delta < 0$ and found to be significant.

The statistical package used to analyse the data is EViews 8.

3.8 Chapterization Scheme:

The chapterization of the thesis is given below:

Chapter I- Introduction:

The research unfolds with chapter one titled introduction. This chapter includes familiarization on commodity, market, commodity markets, commodity derivatives, types of commodity markets, features, merits, participants, evolution, structure, merger of FMC with SEBI and the timeline of commodity derivative market reforms after SEBI- FMC merger.

Chapter II – Review of Literature:

This chapter reviews the scholarly work done by various researchers in the area of commodity derivatives market. The research work done by various researchers on the status of commodity derivatives market, relationship between commodity spot and futures market and its relationship with equity markets have been examined.

Chapter III- Research Methodology and Design:

This chapter begins with introduction to commodity derivative markets, statement of problem, research gap, significance of the study, objectives of the study, scope of the study, research hypotheses, research methodology- sources of data, period of study, sample size, statistical tools and models, chapterization scheme and limitations of the study.

Chapter IV- Present Status, Trading Patterns and Trends in the commodity derivative market in India:

This chapter states the commodity exchanges in India and presents the value of trading in the Indian commodity derivatives market, market share of commodity exchanges, major group of commodities traded in commodity derivatives market in India, share of the commodities traded at the commodity exchanges namely MCX and NCDEX. It also lists out the challenges and problems hindering the development of commodity derivatives market in India.

Chapter V- Price Discovery and Volatility Spillover in Spot and Futures Commodity Markets:

This chapter examines the relationship, price discovery and volatility spillover in spot and futures commodity markets namely MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL. The empirical analysis and discussion is conducted by employing descriptive statistics, unit root test using Augmented Dickey-Fuller (ADF) Test and Phillips Perron (PP) Test, Johensen Cointegration Test, Vector Error Correction Models (VECM), ARCH and Bivarate EGARCH Models.

Chapter VI- Price Discovery and Volatility Spillover in Spot and Futures Prices of Individual Commodities in the Indian Commodity Market:

This chapter investigates the price discovery and volatility spillover in individual commodity spot and futures prices representing agricultural commodities, bullion, energy and metals traded on commodity exchanges namely MCX and NCDEX. The empirical analysis and discussion is conducted by employing descriptive statistics, unit root test using Augmented Dickey-Fuller (ADF) Test and Phillips Perron (PP) Test, Johensen

Cointegration Test, Vector Error Correction Models (VECM), ARCH and Bivarate EGARCH Models.

Chapter VII- Linkages and Volatility Spillover among MCX Commodity Markets and NSE NIFTY Market:

This chapter analyses the linkages of MCX commodity derivates markets on the NSE Nifty equity markets in India namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL on NSE NIFTY market. The chapter evaluates the long run and short run co-movements and volatility spillover between the MCX commodity markets and NSE Nifty equity market in India. The empirical analysis and discussion is conducted by employing descriptive statistics, unit root test using Augmented Dickey-Fuller (ADF) Test and Phillips Perron (PP) Test, Johensen Cointegration Test, Vector Error Correction Models (VECM), ARCH and Bivarate EGARCH Models.

Chapter VIII- Linkages and Volatility Spillover among MCX Commodity Markets and BSE SENSEX Market:

This chapter analyses the linkages of MCX commodity derivates markets on the BSE SENSEX equity markets in India namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL on BSE SENSEX market. The chapter evaluates the long run and short run co-movements and volatility spillover between the MCX commodity markets and BSE SENSEX equity market in India. The empirical analysis and discussion is conducted by employing descriptive statistics, unit root test using Augmented Dickey-Fuller (ADF) Test and Phillips Perron (PP) Test, Johensen Cointegration Test, Vector Error Correction Models (VECM), ARCH and Bivarate EGARCH Models.

Chapter IX- Summary Findings, Conclusions and Suggestions:

This chapter deals with summary findings drawn from the empirical study and discussion, conclusions based on the findings of the current study and suggestions in the form of policy alternatives made by the researcher to draw the attention of the authorities for the further development of commodity derivatives market based on the empirical study of commodity derivates and its impact on equity markets in India. The chapter ends with the areas for further research.

3.9 Limitations of the Study:

The limitations of the research can be listed as:

1. The commodity derivatives market study is restricted to the main national level commodity exchanges namely MCX and NCDEX. The other national level commodity exchanges and regional commodity exchanges are not covered in the study.

2. The impact of commodity derivatives market on equity market is restricted only to NSE NIFTY and BSE SENSEX. The other indices of NSE and BSE are not considered in the study.

CHAPTER 4

PRESENT STATUS, TRADING PATTERNS AND TRENDS IN THE COMMODITY DERIVATIVES MARKET IN INDIA

4.1 Introduction:

One of the interesting developments in the last decade has been the growing popularity of commodity derivatives. The market has made gargantuan evolvement in terms of technology, transparency and trading activity. Intriguingly, this has transpired only after the Government prohibition was removed and market forces were allowed to play their role. The commodity derivatives segment remained underdeveloped due to Government intervention in many commodities to control prices.

Commodity trading in India has a long history. Faced with the grudging reluctance to modernise and slow pace of introduction of fair and transparent structures by the existing exchanges, Government allowed setting up of new modern, demutualised Nation-wide Multi-commodity Exchanges with investment support by public and private institutions. As per the recommendation of the then commodity market regulator Forwards Market Commission (FMC) which is now merged with SEBI, the Government of India recognized the NMCE Ltd., MCX Ltd. and NCDEX Ltd. as nation-wide multi commodity exchanges.

4.2 Commodity Exchanges in India:

The commodity exchanges in India are classified into six national level commodity exchanges and the sixteen regional commodity exchanges offering futures trading activities in 146 commodities.

4.2.1 National Level Commodity Exchanges are:

1. **NCDEX** (National Commodity Derivatives Exchange Limited, Mumbai)
2. **NMCE** (National Multi Commodity Exchange of India Limited, Ahmadabad)
3. **MCX** (Multi Commodity Exchange of India Limited, Mumbai)
4. **ICEX** (India Commodity Exchange Limited, New Delhi)
5. **UCX** (Universal Commodity Exchange Limited, Mumbai)
6. **ACE** (Ace Derivatives and Commodity Exchange Limited, Mumbai)

4.2.2 Regional Exchanges

Sr.	Name
1.	The Bombay Commodity Exchange Ltd
2.	The Meerut Agro Commodities Exchange Co. Ltd.
3.	The Spices and Oil Seeds Exchange
4.	India Pepper And Spice Trade Association
5.	Rajdhani Oils and Oilseeds Exchange Ltd.
6.	National Board of Trade(NBOT), Indore
7.	The Chamber of Commerce
8.	The Central India Commercial Exchange Ltd.
9.	The East India Jute & Hessian Exchange Ltd.
10.	First Commodity Exchange of India
11.	Bikaner Commodity Exchange Ltd.
12.	The Coffee Futures Exchange India Ltd.
13.	Suredranagar Cotton oil and Oil seeds Assoc. Ltd.
14.	Cotton Association of India
15.	Vijay Beopar Chamber Ltd.
16.	Rajkot Commodity Exchange Ltd.

4.2.3 Multi Commodity Exchange of India Limited (MCX):

The MCX Ltd. is a de-mutualised and independent exchange with recognition from Central Government, having its head office in Mumbai. The majority share holders of MCX are Financial Technologies (India) Limited, Corporation Bank of India, State Bank of India, Union Bank of India, Canara Bank and Bank of India. MCX is an exchange which is into online commodity derivatives trading, clearing and settlement.

MCX commenced trading in November 2003 and has collaboration with Bombay Metal Exchange, Bombay Bullion Association, Pulses Importers Association, Shetkari Sanghatana and Solvent Extractors Association of India. MCX offers trading in more than 100 commodities. MCX is known more for non agricultural commodity derivatives trading.

In 2012, MCX was ranked third among the global commodity exchanges in terms of trading in the number of futures contracts. MCX is the first to issue an IPO by any Indian commodity exchange.

The highly traded commodity at MCX is gold. It has several strategic collaborations with the leading commodity exchanges globally. MCX COMDEX is the India's first and only composite commodity derivatives price index.

Commodities Traded at MCX:-

- **Bullion:-**

  Gold, Silver Coins and Silver

- **Oil and Oil seeds:-**

  Groundnut oil, Mustard/ Rapeseed oil, /Refined Soy Oil, Castor oil/castor seeds, Crude Palm oil/ RBD, Palmolein, Sunflower oil, Sunflower Oil cake, Soy seeds/Soy meal, Tamarind seed oil, Coconut Oil Cake and Copra

- **Plantation:-**

  Rubber, Betel nuts, Areca nut, Coconut, Coffee and Cashew Kernel

- **Pulses:-**

  Masur, Urad, Chana, Yellow peas and Tur

- **Minerals:-**

  Zinc, Copper, Tin, Nickel, Lead, Aluminium and Iron/steel

- **Spices:-**

  Jeera, Cinnamon, Red Chilli, Ginger, Pepper, Cardamom and Clove

- **Grains:-**

  Maize, Rice/ Basmati Rice, Wheat, Bajara and Barley

- **Energy:-**

  Brent Crude Oil, Furnace Oil, Natural Gas, Middle East Sour Crude Oil and Crude Oil

- **Fiber and others:-**

  Cotton Cloth, Kapas, Cotton, KapasKhalli, Cotton Yarn, Gaur seed, Gur, Guargum, Mentha Oil, Sugar, Jute Goods, Jute Sacking, Khandsari, Art Silk Yarn, Potato, Chara or Berseem and Raw Jute

- **Petrochemicals:-**

  Polypropylene (PP), Poly Vinyl Chloride (PVC) and High Density Polyethylene (HDPE)

4.2.4 National Commodities and Derivatives Exchange Limited (NCDEX):

The NCDEX Ltd. is a commodity derivatives exchange promoted by ICICI Bank Limited (ICICI Bank), Punjab National Bank (PNB), Canara Bank, National Stock Exchange of India Limited (NSE), National Bank of Agriculture and Rural Development (NABARD), Indian Farmers Fertilizer Cooperative Limited (IFFCO), Credit Rating Information Service of India Limited (CRISIL), Goldman Sachs and Life Insurance Corporation of India (LIC) by contribution to the equity share capital as joint promoters of the commodity derivatives

exchange. NCDEX is the only commodity exchange in India which is promoted by national level financial institutions.

NCDEX was started on 23 April 2003 as a public limited company. NCDEX is a national level commodity derivatives exchange. It is driven by technology and is managed by professionals and independent Board of Directors not having any undue interest in the commodity derivatives markets.

NCDEX offers world class commodity exchange trading experience to the market participants to transact in a wide range of commodity derivatives being professionally run incorporating the global practices and transparency.

NCDEX has its head office in Mumbai and offers commodity derivatives trading to its members in more than 550 centres throughout the country. NCDEX presently offers trading in more than 57 commodities. NCDEX is known more for trading in agricultural commodities.

Commodities Traded at NCDEX:-

- **Bullion:-**

  Gold KG and Silver

- **Energy:-**

  Furnace oil and Crude Oil

- **Oil and Oil seeds:-**

  Oil cake, Cotton seed, Groundnut (in shell), Mentha oil, Palmolein oil, Crude Palm Oil, Refined soya oil, Rape seeds, Castor seeds, Yellow soybean, Cotton, RM seed oil cake, Mustard seeds and Groundnut expeller Oil.

- **Spices:-**

  Pepper, Turmeric and Jeera

- **Grain:-**

  Barley, Indian Basmati Rice, Indian raw Rice (ParmalPR-106), Wheat, Indian parboiled Rice (IR-36/IR-64) and Yellow red maize

- **Minerals:-**

  Nickel Cathode, Aluminium Ingot, Mild steel Ingots, Zinc Metal Ingot and Electrolytic Copper Cathode

- **Pulses:-**

  Masoor, Tur, Chana, Urad and Yellow peas

- **Fibers and other:-**

  Jute sacking bags, Indian 31mm cotton, Lemon, Medium Staple, Green Cottons, Guar seeds, Potato, Mulberry raw Silk, Sugar, Guar Gum, Indian 28 mm cotton, Grain Bold, Mulberry, Raw Jute, V-797 Kapas, Chilli LCA334 and Guar

- **Plantation:-**

  Coffee Robusta, Coffee Arabica and Cashew

4.2.5 National Multi-Commodity Exchange of India Limited (NMCE):

The NMCE Ltd. is the first technologically advanced electronic, demutualised, multi-commodity exchange in India based in Ahmadabad. It is promoted by Gujarat Agro-Industries Corporation Ltd. (GAICL), Central Warehousing Corporation (CWC), Gujarat State Agricultural Marketing Board (GSAMB), National Agricultural Cooperative Marketing Federation of India (NAFED), Neptune Overseas Ltd., (NOL), National Institution of Agricultural Marketing (NIAM), and Punjab National Bank. NMCE offers

commodity trading in food grains, spices, metal, bullion, cash crops, plantations and oil seeds etc.

4.2.6 Indian Commodity Exchange Ltd. (ICEX):

ICEX Ltd. was established in 2009 as a national electronic, reliable, time-tested and transparent derivatives exchange. It has its head office based in Mumbai and regional offices with an aim to facilitate farmers, actual users and traders, to participate in insuring their risk of prices. ICEX is promoted by Reliance Exchange Next Infrastructure Ltd, India bulls financial Services Ltd, KRIBHCO, MMTC Ltd, IDFC and Indian Potash Ltd. It offers commodity trading in energy, agricultural commodities, base metal and bullion.

4.2.7 ACE Derivatives and Commodity Exchange Ltd. (ACE):

ACE (ACE Derivatives and Commodity Exchange Ltd.) have been incorporated by HAFED (Haryana State Cooperative Supply & Marketing Federation Ltd.), Bank of Baroda, Union Bank of India, Corporation Bank and Kotak Mahindra Group. It offers commodity derivatives trading in guar gum, oil, sugar, pluses, fibre and oilseeds.

4.2.8 Universal Commodity Exchange Limited (UCX):

UCX Ltd. is started by NABARD, Rural Electrification Corporation Ltd (REC), IDBI Bank, COMMEX Technology and Indian Farmers Fertilizer Cooperative Ltd (IFFCO). The UCX commodity exchange offers trading in chana, mustard seed, refined soya oil, rubber, turmeric, soya bean, silver, gold and crude oil.

4.3 Value of Commodity Trading:

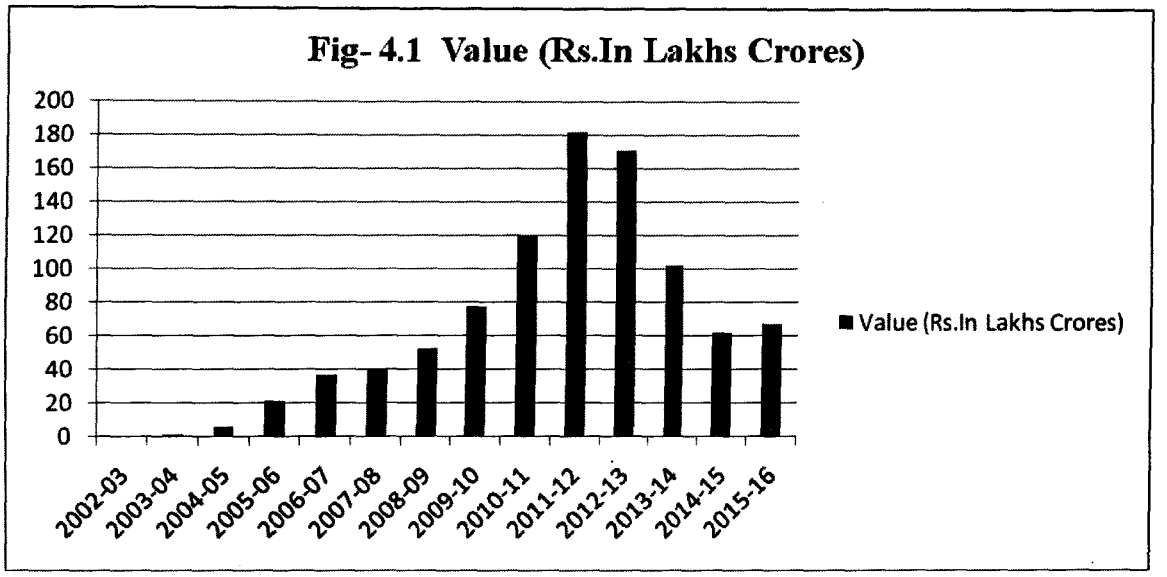
Table 4.1 and figure 4.1 shows the value commodity trading since the year 2002-2003 to 2015-2016

Table - 4.1 Value of Commodity Trading

Year	Value (Rs.In Lakhs Crores)
2002-03	0.66
2003-04	1.29
2004-05	5.72
2005-06	21.55
2006-07	36.77
2007-08	40.65
2008-09	52.49
2009-10	77.64
2010-11	119.48
2011-12	181.26
2012-13	170.46
2013-14	101.44
2014-15	61.68
2015-16	66.96

Source: FMC & SEBI Annual Reports

Fig- 4.1 Value (Rs.In Lakhs Crores)



The above table- 4.1 and figure- 4.1 shows the growth of commodity derivatives trading in terms of value. The consistent growth witnessed in Indian commodity derivative market since the year 2002-03 has continued over the years. The commodity trading in terms value increased manifold from Rs. 0.66 lakh crore in 2002-03 to its peak to Rs.181.26 lakh crores in the year 2011-2012. The sum total of trading dropped marginally to Rs.170.46 lakh crores in the year 2012-2013 for the first time and subsequently to Rs. 101.44 lakh crores in

the year 2013-2014 and to Rs. 61.68 and 66.96 lakh crores in the year 2014-2015 and 2015-2016 respectively on account of NSEL payment crises and introduction of Commodity Transaction Tax (CTT) on commodity trading.

4.4 Market Share of Commodity Exchanges:

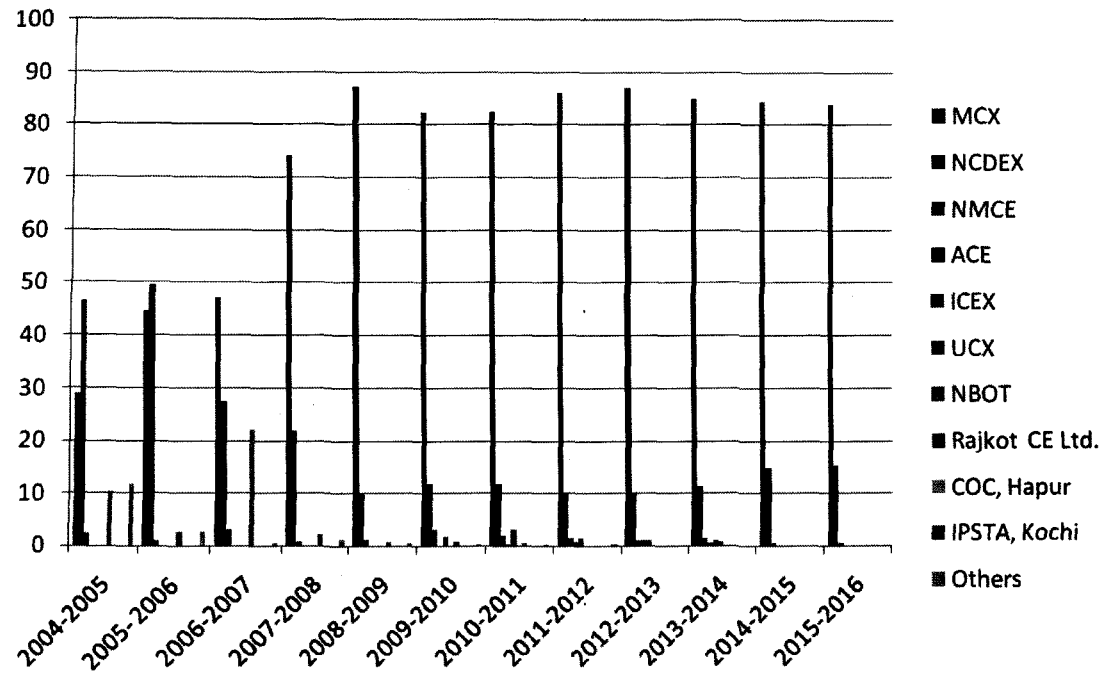
The adjoining table 4.2 and figure 4.2 highlights the market share of commodity derivative exchanges since the year 2004-2005 to 2015-2016.

Table - 4.2 Market Share of Commodity Exchanges

Exchange	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
MCX	28.88	44.62	47.09	74.22	87.41	82.34	82.36	86.05	87.00	84.89	84.48	84.13
NCDEX	46.59	49.5	27.41	21.73	10.21	11.82	11.81	9.99	10.00	11.30	14.73	15.22
NMCE	2.45	0.85	2.95	0.71	1.17	2.94	1.83	1.48	1.00	1.51	0.58	0.43
ACE							0.25	0.76	1.00	0.46		
ICEX						1.76	3.16	1.42	1.00	0.84		
UCX										0.72		
NBOT	10.22	2.49	21.98	2.21	0.65	0.78	0.43					
Rajkot CE Ltd.											0.05	0.02
COC, Hapur											0.13	0.16
IPSTA, Kochi											0.001	0.001
Others	11.86	2.54	0.57	1.13	0.56	0.36	0.16	0.30	0.01		0.028	0.039

Source: FMC & SEBI Annual Reports

Fig 4.2 Share of Major Commodity Exchanges to the total value of Commodities



Source: FMC & SEBI Annual Reports

The above table 4.2 and figure 4.2 shows the market share of the various commodity exchanges during the years since 2004-05 to 2015-16. The growth witnessed in trading has been primarily propelled by National Commodity Exchanges more specifically Multi Commodity Exchange (MCX) Mumbai, and National Commodity Derivatives Exchange (NCDEX) Mumbai accounting for a major quantum of the commodities being traded on the commodity exchanges.

MCX emerged as the largest commodity derivatives exchange since 2006-2007 accounting for more than 80% market share in recent years followed by NCDEX in the commodity derivatives market in India. As the largest commodity exchange in India, the growth of MCX is comparable with some of the international commodity derivatives exchanges. Even though there are 22 commodity exchanges in India, the six major national exchanges accounted for more than 99% of the total value of trade.

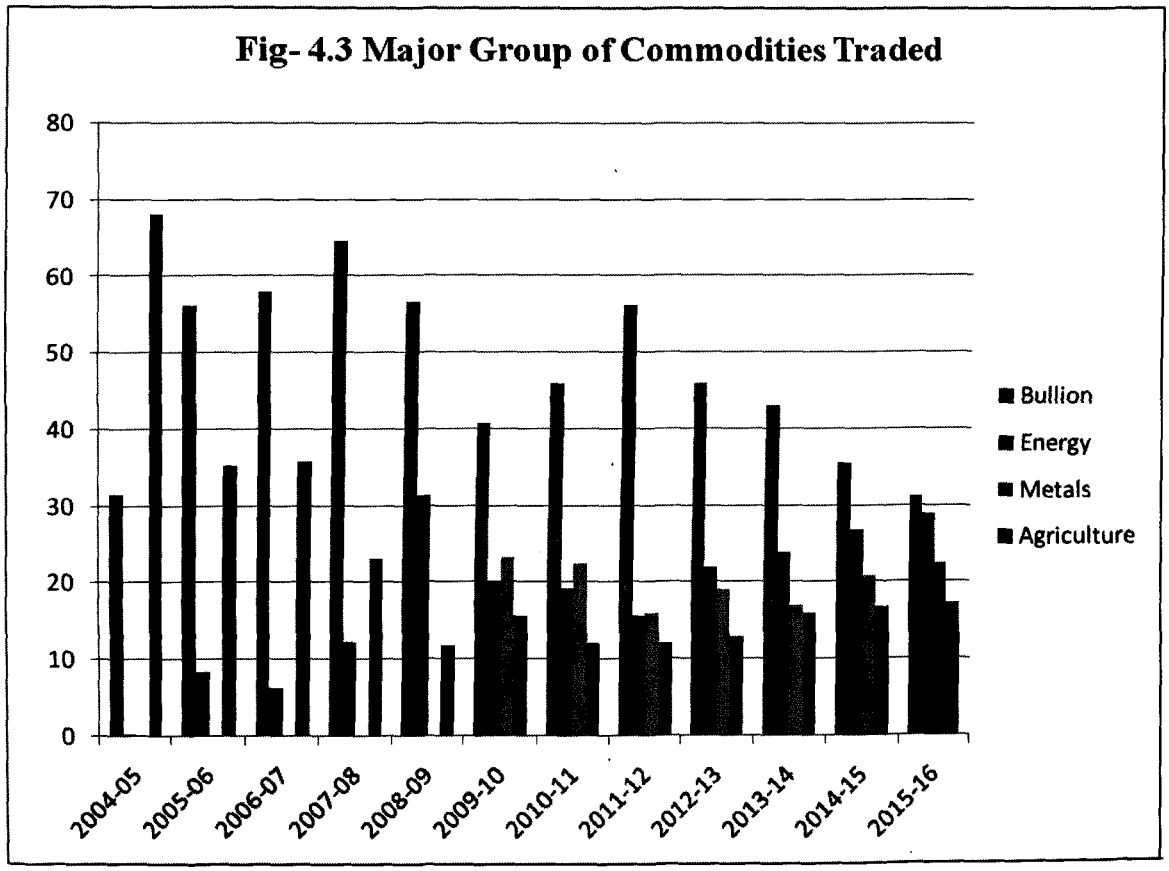
4.5 Major Group of Commodities Traded:

The table 4.3 and figure 4.3 shows the major group of commodities being traded at the commodity exchanges under the broad group of agriculture, bullion, energy and metals.

Table – 4.3 Major Group of Commodities Traded

	2004 -05	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
Bullion	31.5	56.2	57.9	64.6	56.7	40.8	45.98	56.17	46	43	35.63	31.22
Energy	0.3	8.4	6.3	12.3	31.4	20.3	19.34	15.74	22	24	26.83	28.93
Metals	-	0.1	-	-	-	23.2	22.5	15.98	19	17	20.77	22.48
Agriculture	68.2	35.3	35.8	23.1	11.9	15.7	12.18	12.11	13	16	16.77	17.37

Source: FMC & SEBI Annual Reports



Source: FMC & SEBI Annual Reports

The above table 4.3 and figure 4.3 shows the segment wise trend in the commodities being traded since 2004-2005. It is observed that initially when commodity derivatives trading got introduced the major share of trading was in agriculture followed by bullion and other metals. Subsequently from 2005-06 onwards till 2007-08, major trading was in bullion followed by agriculture, metals and energy. From 2009-10 to 2011-12 bullion retained its highest percentage share of the commodities traded in all commodity derivatives exchanges in India followed by metals, energy and agriculture. Since 2012-13 to 2015-16 the major share has been retained by bullion followed by energy, metals and agriculture. Even though India is an agricultural surplus economy, trading in non-agricultural commodities have dominated since the year 2005-06 to 2015-16.

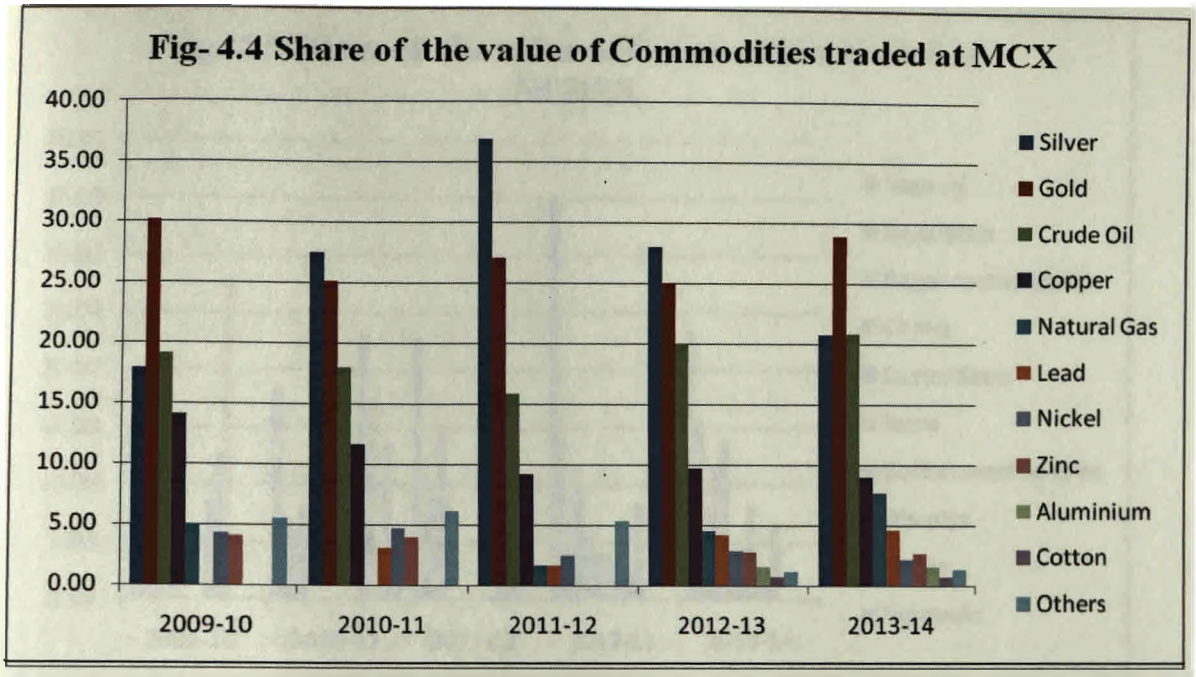
4.6 Share of the value of Commodities Traded at MCX:

The table 4.4 and figure 4.4 shows the value of major commodities being traded at MCX.

Table - 4.4 Share of the value of Commodities traded at MCX

Commodities	2009-2010	2010-2011	2011- 2012	2012-2013	2013-2014
Silver	17.86	27.44	36.79	27.96	20.68
Gold	30.07	25.09	27.09	25.00	28.83
Crude Oil	19.07	17.92	15.79	20.04	20.84
Copper	14.13	11.64	9.21	9.70	9.02
Natural Gas	5.04		1.67	4.52	7.61
Lead		3.11	1.66	4.14	4.63
Nickel	4.31	4.72	2.47	2.90	2.17
Zinc	4.07	3.96		2.80	2.66
Aluminium				1.54	1.57
Cotton				0.72	0.73
Others	5.46	6.12	5.30	1.17	1.28

Source: FMC Annual Reports



Source: FMC Annual Reports

4.7 Share of the value of Commodities Traded at NCDEX:

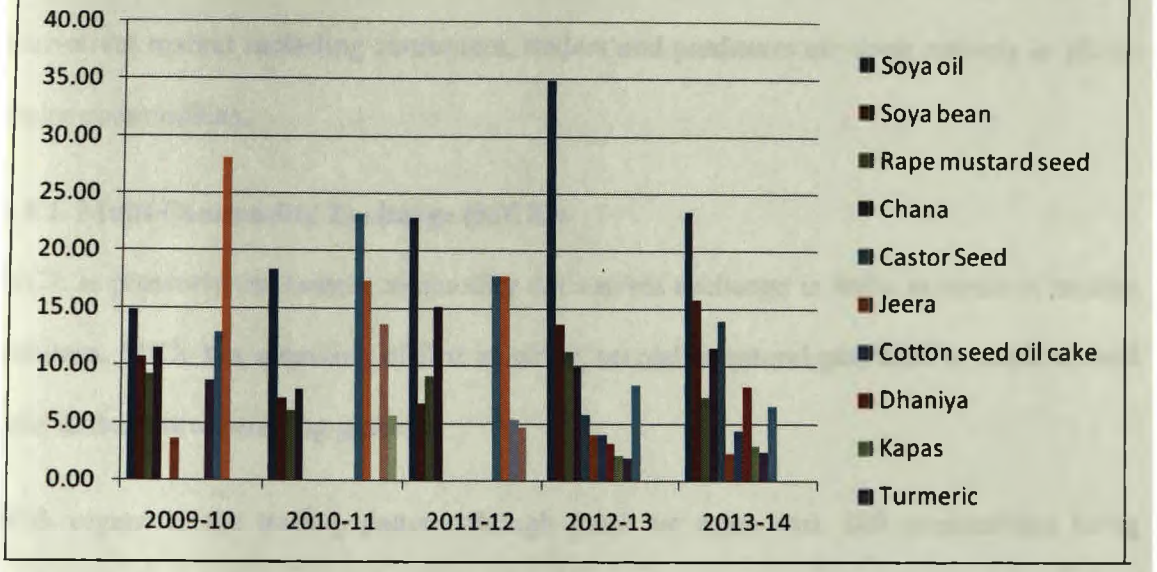
Table 4.5 and figure 4.5 shows the value of major commodities being traded at NCDEX.

Table - 4.5 Share of the value of Commodities traded at NCDEX

Commodities	2009-10	2010-11	2011-12	2012-13	2013-14
Soya oil	14.89	18.46	22.97	34.88	23.55
Soya bean	10.78	7.21	6.77	13.64	15.90
Rape mustard seed	9.24	6.18	9.14	11.27	7.35
Chana	11.58	7.99	15.17	9.98	11.60
Castor Seed				5.87	14.05
Jeera	3.67			4.13	2.52
Cotton seed oil cake				4.10	4.45
Dhaniya				3.31	8.31
Kapas				2.30	3.09
Turmeric	8.71			2.07	2.58
Other Commodities	12.99	23.31	17.90	8.46	6.59
Gur seed	28.12	17.46	17.85		
Gur Gum			5.43		
Crude Oil		13.69	4.76		
Pepper		5.70			

Source: FMC Annual Reports

Fig- 4.5 Share of the value of Commodities traded at NCDEX



Source: FMC Annual Reports

MCX has majority trading in non- agricultural commodities with gold, silver, crude oil, copper and natural gas accounting for the major share of the commodities being traded at MCX. Globally, MCX ranks no.1 in silver, no. 2 in natural gas and no. 3 in crude oil and gold derivatives trading. NCDEX is known more for trading in agricultural commodities with soya oil, soyabean, chana, castor seeds and dhaniya accounting for the majority trading. Since the merger of FMC with SEBI details information about percentage of major commodities traded at MCX and NCDEX is not provided in the annual report of SEBI.

4.8 Trading patterns and trends in the major national commodity exchanges:

Analysis of volume contributions on the major national commodity derivatives exchanges revealed that majority of the trade has been concentrated in few commodities and major volume has been contributed by non agricultural commodities namely bullion, energy and metals. Agricultural commodities have small market size in commodities like soya oil, soyabean, guar, chana, castor seed, dhaniya etc. There is no wide spread involvement of all

the stake holders in the commodity derivatives markets. The actual benefits of commodity derivatives could have been achieved only when all the stake holders in commodity derivatives market including consumers, traders and producers etc trade actively in all the major commodities.

4.8.1. Multi Commodity Exchange (MCX):

MCX is presently the largest commodity derivatives exchange in India in terms of trading volumes. MCX has a ranking of first in silver, second in natural gas, third in crude oil and gold in derivatives trading globally.

With regard to the trading pattern, though there are more than 100 commodities being traded at MCX, but only four commodities contribute to more than 80 percent of total trade volume. The major traded commodities at MCX are gold, silver, crude oil and base copper. The futures commodity price trends of these commodities are primarily driven by international futures prices without much consideration to the domestic factors and as such, the price trends largely reflect international developments.

Among the agricultural commodities being traded the major volume is contributed by Gur, Urad, Mentha Oil etc. whose market sizes are considerably small making them exposed to market manipulations.

2. National Commodity and Derivatives Exchange (NCDEX):

NCDEX is the second largest commodity derivatives exchange in the India after MCX. Furthermore, the major traded commodities on NCDEX are agricultural commodities. More than 60 percent commodity trading on NCDEX is from soya oil, soyabean, chana and castor seeds. But, most of agricultural commodities being traded on NCDEX have the main

problem of small sized market, which exposes them to over speculation and market manipulations.

4.9 Challenges and Problems faced by Commodity Derivatives Market in India:

1. Constitution of exchanges: All commodity exchanges in India are mutual organizations. They are promoted by traders who carryout trading as well as manage the exchanges. The exchange staff including the chief executive officer/secretary is the staff of promoters. This structure poses a serious threat to the integrity of exchanges. The structure needs to be altered so as to ensure an arm's length relationship between those who promote and manage the exchange on the one hand and those who have trading interest in exchanges on the other. Many leading exchanges in the world are demutualized organizations where arms length relationship between management and trading is maintained.

2. Commodity Options: Trading in commodity option contracts have been banned since 1952. The market for commodity derivatives cannot be called complete without the presence of this important derivative. Both future and options are necessary for the healthy growth of the market.

3. Infrastructure: Lack of efficient and modern infrastructural facilities are a major bottleneck in the growth of futures markets in India. Though some of the exchanges own huge office premises, they lack necessary institutional infrastructure including warehousing facilities, independent clearing house in addition to modern trading ring. The Kanpur Commodity Exchange for example, lacks basic facilities to disseminate the trading information. The exchange has only a couple of small office rooms and a poorly maintained trading ring which seems to have never been utilized.

4. Trading system: Most of the regional exchanges except the national level six exchanges till date have open outcry system. The Forward Markets Commission and SEBI has been emphasizing the need for automation and on-line trading system for ensuring better transparency and fairness in trading practices in the regional commodity exchanges. It has been observed that few members are only actively trading in these exchanges. Volume of trade has been consistently declining. An active and vibrant market is necessary for introducing electronic trading system. Steps have to be initiated for creating market and making the exchange financially sound for investing in automation and on-line trading. The Coffee Futures Exchange, Bangalore where automation was introduced which did not encourage the traders consequent to which volume dropped leaving a large financial burden. Moreover, majority of trading members in some of the exchanges are not educated enough to handle english and to operate computer without which computer based trading is almost impractical.

5. Warehousing and Standardization: For commodity derivatives market to work efficiently it is necessary to house a sophisticated, cost effective, reliable and convenient warehousing system in the country. There is a need for institutional creation of a new service sector with public private partnership (PPP) to deal with the standardization and grading of agricultural produce. A policy directive can ensure that certain percentage of contracts can be linked to compulsory physical delivery and off take to avoid too much of speculation.

6. Cash versus physical settlement: A good delivery system is the backbone of any commodity trade. A practical difficulty in cash settlement of commodity derivative contracts is that under the Forward Contract (regulation) Act 1952, cash settlement of outstanding contracts at maturity was not allowed. This implies that all outstanding contracts at maturity should be settled in physical delivery. To avoid this situation,

participants square off their positions before maturity resulting in most contracts being settled in cash.

7. **Broking community**: Although a large number of members exist in the records of exchanges, most of them shy away from trading due to the fact that the business is not very profitable. It is essential to attract large scale broking firms who have diversified into stock broking and other related businesses. Regulation including setting standards for brokers, imposing capital adequacy norms, qualification criterion, etc would become more meaningful when more and more active traders are attracted to the business.

8. **Regulator:** The commodity derivatives markets needed a strong and independent regulator as the then FMC was under the department of consumer affairs. The Government should have granted more powers to the FMC, to ensure the orderly development of the commodity markets. This has been resolved with the FMC being merged with SEBI from September 2015 which would bring the much needed autonomy to the commodity market regulator.

9. **Existence of unofficial market**: The grey/black market which existed outside the exchange premises during the ban on futures trading still continues to exist even inside the exchanges. It has been widely accepted and admitted by some of the CEOs/Secretaries of exchanges that major trade in the exchanges go unreported. The unofficial market operating outside the official exchange is much larger. These unofficial traders find the margin, stamp duty and income tax requirements least encouraging to come to the official contract channels.

10. Lack of Economies of Scale: There are six national and sixteen regional commodity exchanges, through which 113 commodities are allowed for derivatives trading, however derivatives are popular for only a few commodities. Also, most of the trade takes place on a few exchanges, resulting in volumes being split and making some exchanges unviable. This problem can possibly be addressed by consolidating some exchanges to bring in economies of scale and enhance their scope, thus boosting the growth of commodity derivatives market.

11. Multiplicity of exchanges: Currently twenty two exchanges are operational of which six are national exchanges and 16 are regional exchanges. Many of these exchanges are set up as specialized ones for trading in one or a few commodities. NCDEX is known more for trading in agricultural commodities whereas MCX is a leading exchange for trading in bullion, energy and metals. The international experience shows that exchanges are only to provide a platform for trade in many commodities and different forms of contracts. If an exchange provides a well-organised trading system for certain commodities, with well-developed procedures, a good intermediary structure, and a sound clearing house, it can build on these strengths to introduce new products.

12. Tax and Legal Issues: At present restrictions have been placed on the movement of certain goods from one state to another which need to be removed so that a truly national market could develop. Also regulatory changes are required to bring about uniformity in stamp duty, octroi and VAT etc. Introduction of GST will go a long way in ensuring uniformity in taxes on goods. The high stamp duty imposed by the State Government in case of non delivery of transactions has made the market unattractive, leading to an illegal hawala market.

13. Controlled market: Price variability is an essential pre-condition for futures markets. Any distortion in the market mechanism where free play of supply and demand forces for commodities determines prices will dilute the variability of prices and potential risk. It is imperative that for a vibrant futures market commodity pricing must be left to market forces, without monopolistic or undue Government control. However, in India many of the commodities in which futures trading are allowed have been still protected under Essential Commodities Act, 1955. There are also commodity based specialized Government agencies like Cotton Corporation of India, NAFED, Jute Corporation of India, etc. which seek to control supplies of some farm products. The system of administered price mechanism has not only distorted the cropping pattern but has also restricted the scope for adequate development of commodity derivatives markets.

14. Trained Staff: A majority of the members of exchanges face the problem of lack of trained staff in predicting the trends in commodity futures market. Employing agricultural graduates trained by the regulatory authorities and availing of consultancy services offered by the professional agencies could solve this problem to some extent.

15. Fragmented Spot Market: The major stumbling block for the development of derivatives market is the fragmented physical/spot market in India. There is a need to have sound and vibrant physical market so as to ensure a vibrant and transparent derivatives market.

16. Membership: Limited and closed nature of membership particularly in the regional exchange and absence of many hedgers has scuttled the spread of derivatives trading. Due to the small size of commodity exchanges in terms of their turnover, large corporate houses are looking forward to off shore commodity exchanges. Concerted efforts have to be made

to bring the traditional players to the formal market in order to achieve minimum critical liquidity, sufficient breadth and depth and provide relatively less expensive exit route. Lack of awareness about the role and technique of derivatives trading among the potential beneficiaries is hindering the growth of the commodity derivatives market.

17. Shortsighted policy of banning future trading: Banning futures trading in agricultural commodities including basic food grains is not a desirable policy action. Policies to improve spot market functioning, enhance farmers' knowledge of and access to futures markets, augment availability of adequate storage and financing against warehouse receipts and ensure transparent functioning of futures markets, are certainly warranted

18. Quality Output and Price Issues: In India small land holdings, dependence on monsoon, low level of input usage, poor agronomic practices, lack of rural infrastructure (warehousing, grading/sorting facilities, road access to markets), poor flow of price and market information, all combine to translate to unsteady output, sub-standard quality and fluctuating prices. Enhancing the capacity building of farmer organizations can be taken up through NGO's, for facilitating active participation in futures market.

19. Non-rationalisation of CTT: Despite path breaking regulatory changes and a conducive policy framework, the Commodities Transaction Tax (CTT) remains unchanged. India and Taiwan are the only two countries globally to have this tax. Due to CTT, Indian commodity exchanges would continue to remain price takers even in non-agricultural commodities like gold where India's physical market demand remains the highest globally.

CHAPTER 5

PRICE DISCOVERY AND VOLATILITY SPILLOVER IN SPOT AND FUTURES COMMODITY MARKETS

5.1 Introduction:

This chapter investigates the price discovery and volatility spillover in spot and futures commodity markets in India. The spot and futures markets considered for the study are MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

The study investigates whether the spot or the futures markets play a major role in the price discovery process. It evaluates whether there is unidirectional flow of information from the futures market to the spot market, or spot market to the futures market or a bidirectional flow of information between these markets. The results would help to identify the extent of relationship between the futures and spot markets and the speed of adjustments between the markets. Further, the study evaluates whether the volatility spills over from the futures market to the spot market, or spot market to the futures market or a bidirectional flow of volatility between the two markets.

I. Price Discovery

5.2 Descriptive Statistics:

To assess the distributional properties of spot and futures return series of spot and futures markets of respective commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, descriptive statistics are reported in the Table 5.1.

Table- 5.1 Descriptive Statistics of MCX Spot and Futures Commodity Markets Return

Statistics	MCXAGRI		MCXCOMDEX		MCXENERGY		MCXMETAL	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	0.0003	0.0001	0.0002	0.0002	0.00004	0.00006	0.0004	0.0004
Std. Dev.	0.0082	0.0128	0.0123	0.0109	0.0283	0.0173	0.0126	0.0163
Skewness	-1.5675	-2.3099	-0.0582	-0.3942	-0.0646	-0.0819	-0.9244	-0.2311
Kurtosis	169.73	111.39	37.654	6.8596	238.69	6.2580	13.322	158.89

Jarque-Bera Statistics	2782326* (0.000)	1177471* (0.000)	120144* (0.000)	1552* (0.000)	5557564* (0.000)	1064* (0.000)	11001* (0.000)	2431309* (0.000)
Observations	2401	2401	2401	2401	2401	2401	2401	2401
Note: * – indicates significance at one per cent level. Probability Values are in Parenthesis.								

Table results show that, on an average, futures and spot markets of respective MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL yielded more or less similar returns. The futures and spot markets of MCXENERGY yield the lowest returns among other commodity markets during the sample period. There is evidence that market returns of futures and spot series of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL are negatively skewed and also the kurtosis values of the market return series was much higher than 3 indicating that the spot and futures return distributions of these commodity markets are fat-tailed or leptokurtic. Besides, the spot and futures return series of these commodity markets are non-normal according to the Jarque-Bera test, which rejects normality at the 1% level.

5.3 Unit Root Test:

Given the time series nature of the data, an initial step in the analysis is to test whether each price or log price series is integrated [I(1)] or stationary [I(0)]. An I(1) time series is said to have a unit root and any shock to the series is permanent. To identify whether the series are I(1), Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests were conducted as described in the methodology section.

Unit root tests are reported in Table 5.2. The ADF and PP test statistics are shown for the log price series and the return series for both the spot and futures indices of commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. Based on Schwarz information criteria, the optimal lag length was chosen for ADF and PP test. Both ADF and PP test statistics indicate that the log price series of all commodities contain unit

root, implying the fact that both the log spot and futures prices series of all commodities are non stationary. The ADF and PP test statistics reject the hypothesis of a unit root at 1% level of significance in return series, implying the fact that the return series are stationary.

Table-5.2 Results of Unit Root Test

Name of the MCX Commodity Indices	Variables	Levels	First Difference	Inference on Integration
Augmented Dickey-Fuller				
MCXAGRI	AGRISPOT	-1.5327	-44.277*	
	AGRIFUTURES	-1.9165	-29.926*	I(1)
MCXCOMDEX	COMEXSPOT	-2.0729	-51.644*	
	COMEXFUTURES	-2.2004	-47.908*	I(1)
MCXENERGY	ENERGYSPOT	-2.2645	-62.688*	
	ENERGYFUTURES	-2.0466	-46.145*	I(1)
MCXMETAL	METALSPOT	-2.2619	-50.418*	
	METALFUTURES	-2.3154	-62.110*	I(1)
Philips-Perron Test				
MCXAGRI	AGRISPOT	-1.5208	-44.929*	
	AGRIFUTURES	-1.9451	-46.999*	I(1)
MCXCOMDEX	COMEXSPOT	-2.0722	-51.589*	
	COMEXFUTURES	-2.1909	-48.040*	I(1)
MCXENERGY	ENERGYSPOT	-2.2331	-63.785*	
	ENERGYFUTURES	-2.0908	-46.142*	I(1)
MCXMETAL	METALSPOT	-2.2609	-50.398*	
	METALFUTURES	-2.2957	-62.007*	I(1)

Notes: * – indicates significance at one per cent level. Optimal lag length is determined by the Schwarz Information Criterion (SIC) for the Augmented Dickey-Fuller Test and Philips-Perron Test.

5.4 Johensen Cointegration Test:

Once the futures and spot price series of each commodity are integrated at same order, Johensen test of cointegration test is employed to confirm the presence of long term linkage involving spot and futures price series of selected commodity markets, respectively. The Johansen Cointegration is sensitive to the selection of optimal lag length and the necessary lag length of futures and spot price series for the respective commodity is determined by the Schwarz Information Criterion (SIC) and it reveals optimal lag of four for MCXAGRI, six

for MCXCOMDEX and MCXENERGY, and five for MCXMETAL. **(Refer Annexure 1- Results of VAR Lag Length Selection)**

Johansen's cointegration test was performed to examine the long-run relationship between the MCX spot and futures commodity markets and its results are presented in Table- 5.3. The results of Johansen's maximum eigen (λ_{max}) and trace statistics (λ_{trace}) indicate the presence of one cointegrating vector between the MCX spot and futures commodity market prices at 5% level respectively.

The empirical results found that there exists long-term equilibrium relationship between spot and future prices in case of all the selected commodity markets. As there are only two series involved, the number of cointegrating vectors can be at most one for each commodity. The hypothesis of no cointegration vector (r=0) can be rejected for all the selected commodities, as the trace statistics are higher than the critical values at 5 % level. Cointegration analysis measures the extent to which two markets have achieved long run equilibrium. Efficiency can be concluded because future prices and spot prices are cointegrated in all the selected commodities since cointegration is a necessary condition for market efficiency.

Table- 5.3 Results of Johansen Cointegration Test

Name of the MCX Commodity Indices	vector (r)	Trace test Statistics (λ_{trace})	Maximal Eigen value (λ_{max})	5 % Critical value for Trace Statistics	5 % Critical value for Max-Eigen Statistics	Remarks
MCXAGRI	H_0: r = 0	20.520**	16.080**	20.261	15.892	*Cointegrated*
	H_1: r ≥ 1	4.4399	4.4399	9.1645	9.1645	
MCXCOMDEX	H_0: r = 0	29.431**	24.995**	25.872	19.387	*Cointegrated*
	H_1: r ≥ 1	4.4361	4.4361	12.517	12.517	
MCXENERGY	H_0: r = 0	115.03**	111.16**	25.872	19.387	*Cointegrated*
	H_1: r ≥ 1	3.8633	3.8633	12.517	12.517	
MCXMETAL	H_0: r = 0	204.48**	197.78**	25.872	19.387	*Cointegrated*
	H_1: r ≥ 1	6.6992	6.6992	12.517	12.517	

Notes: ** – indicates significance at five per cent level. The significant of the statistics is based on 5 per cent critical values obtained from Johansen and Juselius (1990). r is the number of cointegrating vectors. H_0 represents the null hypothesis of presence of no cointegrating vector and H_1 represents the alternative hypothesis of presence of cointegrating vector.

Taking into account the results from both tests, the absence of cointegration relationship is rejected and the existence of at least one cointegration equation is supported. Since there are two variables, it is concluded that there is presence of single cointegration association which is observed between spot and futures prices of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. The subsequent action is to go ahead with Vector Error Correction Model. The results evidence that futures and spot prices of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL lead lag together in the long term.

5.5 Vector Error Correction Model (VECM):

The dynamic VECM representation provides us with a framework to test for the causal dynamics in the Granger sense among the price series through both short-run and error-correction channels (ECTs) of causation. Short-run market causality test will determine whether spot price in different markets respond instantaneously to changes in future prices. The coefficient of the lagged error correction term (ECTs) shows the portion by which the long-run disequilibrium in the dependant variable is being corrected in each short period to have stable long-run relationship. If both short-run causality coefficient and ECTs are insignificant, the market can be treated as exogenous to the system (Masih and Masih 1997). The application of Schwarz Information Criterion (SIC) is used to find the optimal lag for the vector error correction model.

The VECM can be estimated by incorporating the error correction term. The VECM estimates are presented in Table- 5.4. The coefficients of the Error Correction terms (ECTs)

provide some insight into the adjustment process of spot and futures prices towards equilibrium in all types of contracts.

Table- 5.4 Results of Vector Error Correction Model for AGRI, COMDEX, ENERGY and METAL Markets

	MCXAGRI		MCXCOMDEX		MCXENERGY		MCXMETAL	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.0024**	0.0022	-0.0514*	0.0103	-0.3006*	0.0024	-0.2491*	0.2347*
	(0.0011)	(0.0018)	(0.0114)	(0.0132)	(0.0295)	(0.0235)	(0.0250)	(0.0400)
	[-2.1427]	[1.2224]	[-4.4841]	[0.7777]	[-10.185]	[0.1053]	[-9.9547]	[5.8694]
ΔS_{t-1}	0.0266	0.0963*	-0.4992*	0.0805*	-0.4215*	0.0501**	-0.2687*	-0.0244
	(0.0208)	(0.0331)	(0.0231)	(0.0267)	(0.0319)	(0.0254)	(0.0280)	(0.0447)
	[1.2803]	[2.9068]	[-21.579]	[3.0158]	[-13.187]	[1.9697]	[-9.5958]	[-0.5450]
ΔS_{t-2}	-0.0349***	0.1673*	-0.3965*	0.0683**	-0.3106*	0.0706*	-0.2518*	-0.0511
	(0.0208)	(0.0332)	(0.0253)	(0.0292)	(0.0318)	(0.0253)	(0.0266)	(0.0425)
	[-1.6744]	[5.0384]	[-15.645]	[2.3364]	[-9.7647]	[2.7878]	[-9.4696]	[-1.2033]
ΔS_{t-3}	-0.0091	0.0622***	-0.2727*	0.1058*	-0.2272*	0.1080*	-0.1458*	0.0874**
	(0.0205)	(0.0326)	(0.0260)	(0.0300)	(0.0302)	(0.0240)	(0.0240)	(0.0385)
	[-0.4464]	[1.9050]	[-10.489]	[3.5263]	[-7.5242]	[4.4889]	[-6.0629]	[2.2671]
ΔS_{t-4}	0.0104	0.0229	-0.1783*	0.0147	-0.2097*	0.0281	-0.1458*	0.0603***
	(0.0201)	(0.0320)	(0.0251)	(0.02901)	(0.0281)	(0.0224)	(0.0240)	(0.0347)
	[0.5177]	[0.7158]	[-7.0936]	[0.5095]	[-7.4453]	[1.2527]	[-6.0629]	[1.7356]
ΔS_{t-5}			-0.0656*	0.0456***	-0.1220*	0.02692	-0.0066	0.03515
			(0.0214)	(0.0247)	(0.0242)	(0.0193)	(0.0164)	(0.0276)
	---	---	[-3.0623]	[1.8454]	[-5.0375]	[1.3944]	[-0.4043]	[1.2738]
ΔS_{t-6}			-0.0453*	0.0001	-0.0764*	-0.00383		
			(0.0168)	(0.0194)	(0.0184)	(0.0146)		
	---	---	[-2.6835]	[0.0091]	[-4.1524]	[-0.2614]	---	---
ΔF_{t-1}	0.1162*	0.0220	0.5833*	0.0090	0.50659*	0.0426	0.1883*	-0.0591
	(0.0131)	(0.0209)	(0.0214)	(0.0247)	(0.0395)	(0.0315)	(0.0259)	(0.0414)
	[8.8464]	[1.0548]	[27.243]	[0.3675]	[12.799]	[1.3526]	[7.2661]	[-1.4263]
ΔF_{t-2}	0.1292*	-0.0147	0.6079*	-0.0041	0.5038*	-0.0200	0.3414*	0.0754***
	(0.0132)	(0.0210)	(0.0245)	(0.0283)	(0.0397)	(0.0316)	(0.0250)	(0.0400)
	[9.7584]	[-0.7014]	[24.788]	[-0.1468]	[12.680]	[-0.6333]	[13.646]	[1.8874]
ΔF_{t-3}	0.0042	-0.1181*	0.3827*	-0.0491	0.3026*	-0.0807*	0.2515*	0.0874**
	(0.0134)	(0.0214)	(0.0273)	(0.0315)	(0.0395)	(0.0315)	(0.0241)	(0.0385)
	[0.3190]	[-5.5084]	[13.984]	[-1.5576]	[7.6499]	[-2.5607]	[10.418]	[2.2671]
ΔF_{t-4}	0.0293**	-0.0300	0.2652*	-0.0560***	0.3473*	-0.0623**	0.1586*	0.0603***
	(0.0135)	(0.0215)	(0.0277)	(0.0320)	(0.0375)	(0.0299)	(0.0217)	(0.0347)
	[2.1720]	[-1.3929]	[9.5592]	[-1.7494]	[9.2545]	[-2.0823]	[7.2917]	[1.7356]
ΔF_{t-5}			0.1518*	-0.0665**	0.1964*	-0.0594**	0.0828*	0.0351
			(0.0268)	(0.0309)	(0.0360)	(0.0287)	(0.0172)	(0.0276)
	---	---	[5.6624]	[-2.1498]	[5.4549]	[-2.0718]	[4.7970]	[1.2738]
ΔF_{t-6}			0.0757*	-0.0436	0.1059*	-0.0446***		
			(0.0240)	(0.0277)	(0.0330)	(0.0263)		
	---	---	[3.1477]	[-1.5724]	[3.2059]	[-1.6950]	---	---
c	0.0003***	9.34E-05	0.0001	0.0002	-2.13E-05	3.89E-05	0.0002	0.0004
	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0004)	(0.0003)	(0.0002)	(0.0003)
	[1.9054]	[0.3594]	[0.7220]	[0.9394]	[-0.0485]	[0.1112]	[1.4662]	[1.2640]

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SC), F_t and S_t are the Futures and Spot market prices respectively, *, ** and *** denote the significance at the one, five and ten per cent level, respectively.

[ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

The table result shows that coefficients of the ECTs in the spot equations of respective commodity markets such as MCXAGRI, MCXCOMDEX, and MCXENERGY are statistically significant and negative, while the coefficients of the ECTs in the futures equations are found to be statistically insignificant, suggesting a unidirectional error correction. This indicates that when the cost-of-carry relationship is perturbed, it is the spot price that makes the greater adjustment in order to reestablish the equilibrium. In other words, the futures price leads the spot price in price discovery in the case of all respective MCX commodity markets in the long-run except MCXMETAL. That is, the ECT term represents a mean-reverting price process.

For MCXMETAL, the Error Correction coefficient (ECT) in the spot equation is statistically significant, and also the coefficient of the ECT in the futures equation is statistically significant, suggesting a bidirectional relationship between spot and futures market prices in the long-run. However, the error correction term in the spot equation is greater in magnitude than that of the futures equation, suggesting the futures price leads the spot price in price discovery in the long-run.

Furthermore, the empirical evidence indicates that the lagged coefficients of changes in futures prices in spot equations, and the lagged coefficients of changes in spot prices in futures equations are found to be statistically significant in the case of respective commodity viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, implying that both spot and futures markets are informationally efficient and plays a dominant role and serve effective price discovery vehicle in the short-run. These findings are in accordance with previous studies in futures markets. Chan et al. (1991), Chan (1992), and Wahab and Lashgari (1993), amongst others, suggest that there is a bi-directional relationship between derivatives and spot returns.

By and large, the evidences from VECM estimates show unidirectional causation runs from futures prices to spot prices in the long-run for commodity markets such as MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. It means that MCX commodity derivatives markets are highly creative which makes it possible for them to explore the latest information which is available with regard to commodity prices and behaviour of the investors in the commodity derivatives markets. This leads to the fact that future markets have the potential to explore the latest information from its own sources. It means that futures market through innovation possesses the means to uncover extensive quantum of the up to date information.

In addition, there exists bidirectional relationship between spot and futures markets price in the short-run, implying that both spot and futures markets are informationally efficient and play dominant roles as effective price discovery vehicles in the short-run.

II. Volatility Spillover

5.6 ARCH -LM Test:

Furthermore, the Engle (1982) ARCH-LM test statistics was conducted in order to test the null hypothesis of no ARCH effects on the spot and futures markets price series of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and its result are shown in Table 5.5.

Table- 5.5 ARCH LM Test Results of MCX Spot and Futures Commodity Markets Return

Name of the Commodity	ARCH LM Statistics			
	Spot Returns	Prob. Value	Futures Returns	Prob. Value
MCXAGRI	45.324	0.000	53.975	0.000
MCXCOMDEX	630.67	0.000	46.567	0.000
MCXENERGY	664.65	0.000	119.20	0.000
MCXMETAL	99.636	0.000	679.99	0.000

The ARCH-LM test statistics are highly significant at one per cent level, confirming the existence of significant ARCH effects on the spot and futures return data series of commodity markets, namely, MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

Figure 5.1: Volatility Clustering of Spot and Futures Commodity Market Returns of MCXAGRI

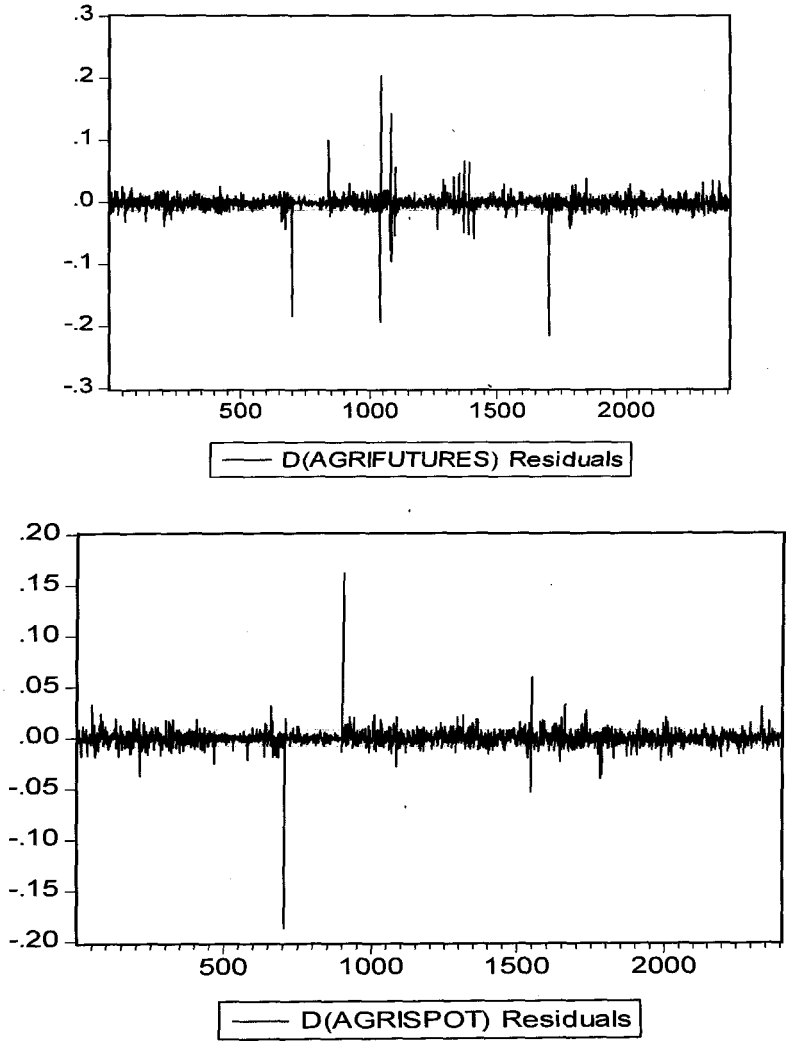
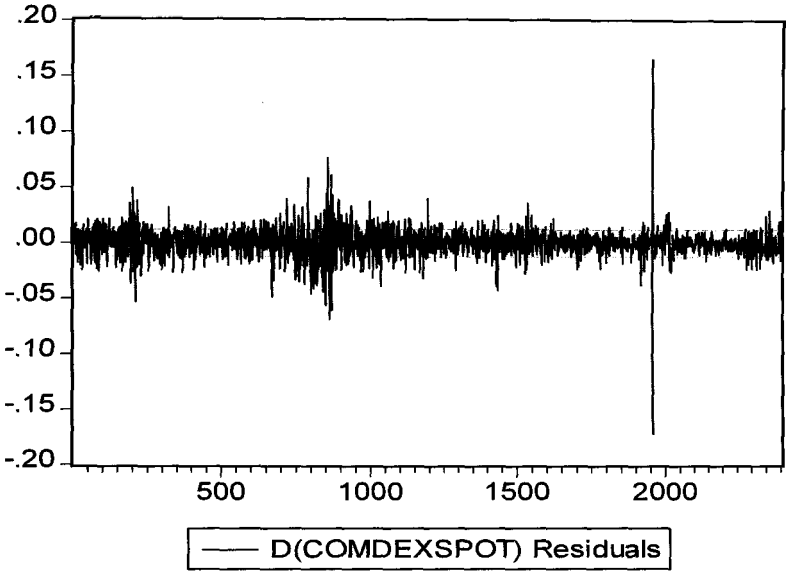


Figure 5.2: Volatility Clustering of Spot and Futures Commodity Market Returns of MCXCOMDEX



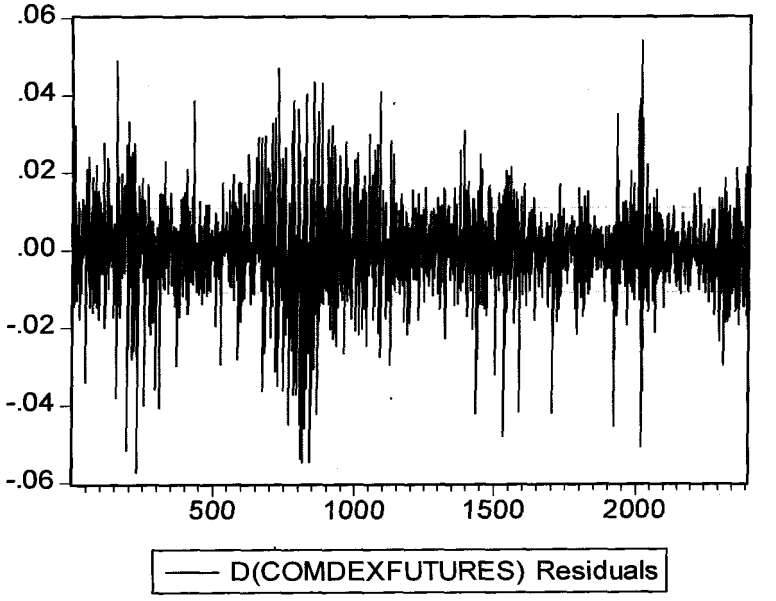
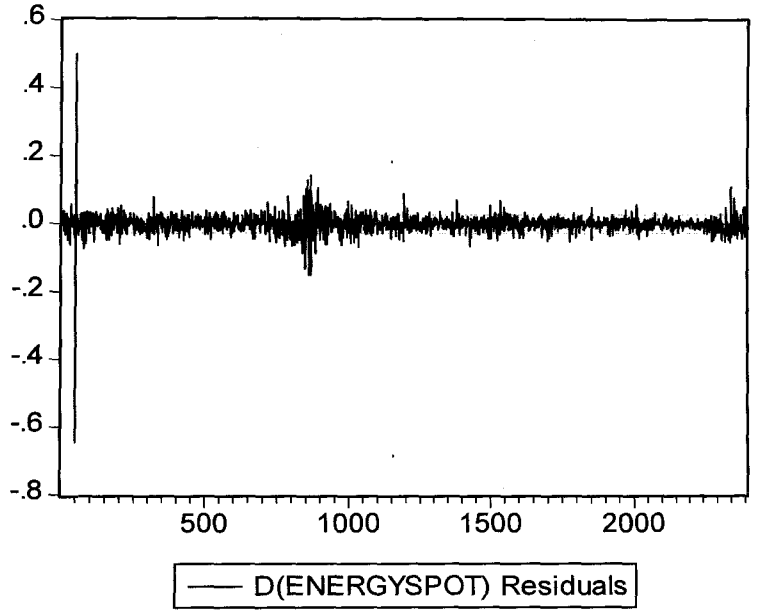


Figure 5.3: Volatility Clustering of Spot and Futures Commodity Market Returns of MCXENERGY



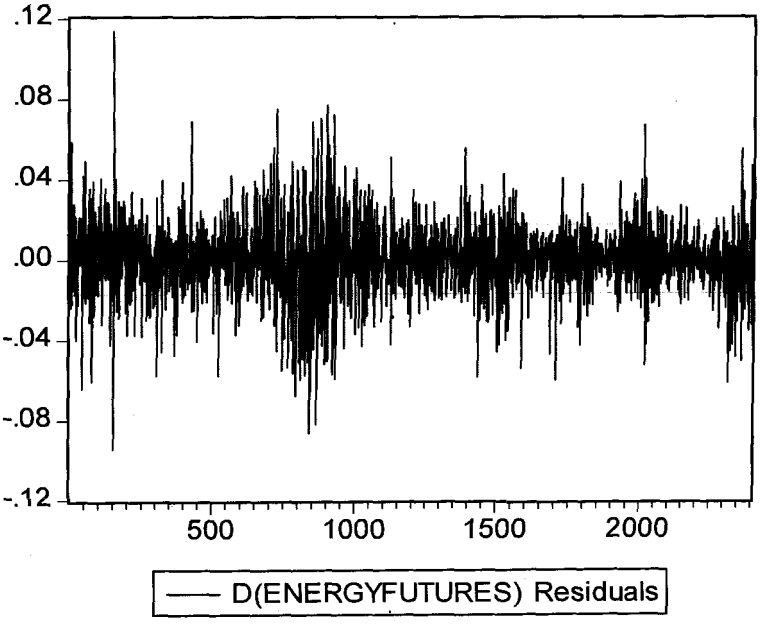
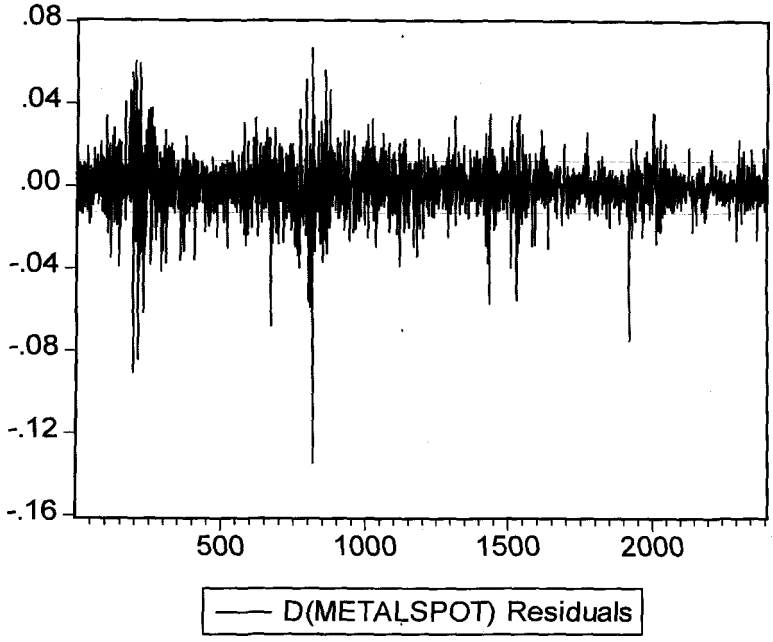


Figure 5.4: Volatility Clustering of Spot and Futures Commodity Market Returns of MCXMETAL



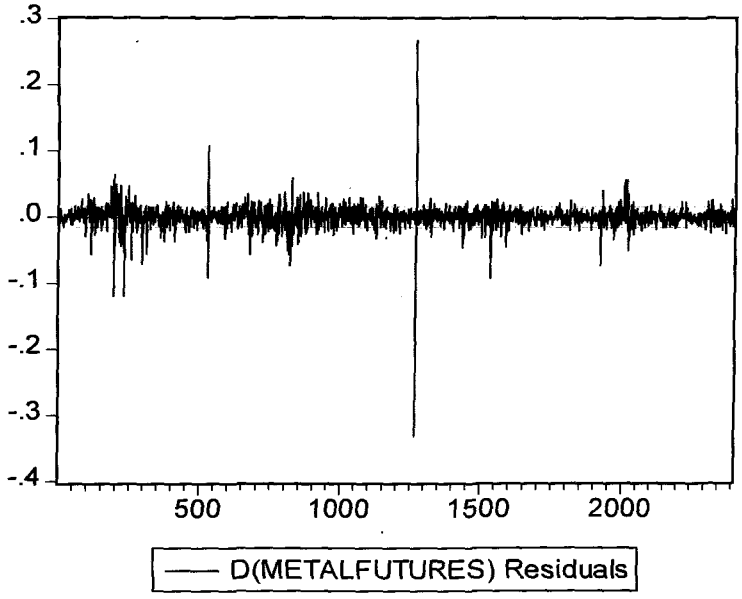


Figure 5.1 to 5.4 shows the volatility clustering of spot and futures commodity market returns of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively. The graphical representation of the residuals obtained from the spot and futures commodity market returns exhibits significant ARCH effects i.e. volatility clustering or volatility persistence.

By and large, the evidence from the ARCH LM test statistics as well as Graphical representation of residual series of commodity market returns suggest that Bivariate EGARCH model adequately maps the heteroscedastic impact and volatility clustering to enable modeling of the return volatility of future and spot prices of the selected markets.

5.7 Bivariate EGARCH Model:

Table 5.6 shows the estimates of the Bivariate EGARCH model which estimates the presence of volatility spillover systems that caused futures and spot prices in commodity markets of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively.

Table- 5.6 Results of Volatility Spillover for the MCX Spot and Futures Commodity Markets

Parameter	MCXAGRI		MCXCOMDEX		MCXENERGY		MCXMETAL	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
ω_i	-17.276* (-67.705)	-0.3456* (-27.533)	-0.2491* (-8.1195)	-0.2993* (-10.978)	-0.1839* (-8.5823)	-0.1550* (-6.8516)	-0.2929* (-11.335)	-3.3646* (-14.147)
ψ_i	0.1412* (9.6061)	0.1570* (35.915)	0.1112* (10.413)	0.1419* (14.879)	0.1867* (12.139)	0.0995* (10.098)	0.1636* (14.670)	0.4918* (12.808)
τ_i	-0.1029* (-8.6031)	-0.0824* (-15.154)	-0.0437* (-4.2699)	-0.0111*** (-1.6796)	-0.0464* (-3.8696)	-0.0160* (-2.9871)	-0.0672* (-7.1983)	-0.1693* (-7.0319)
α_i	-0.7688* (-28.814)	0.9723* (557.33)	0.9808* (340.96)	0.9785* (369.31)	0.9925* (405.58)	0.9900* (440.53)	0.9808* (370.55)	0.6419* (23.678)
γ_i	-10.317* (-18.279)	-5.7682* (-10.041)	5.2287* (9.4594)	-4.6664* (-5.5839)	6.1072* (12.114)	0.0767 (0.2874)	-5.2048* (-13.604)	-10.404* (-7.4233)
Residual Diagnostics								
ARCH-LM Statistics	0.0776 (0.7805)	0.0564 (0.8122)	1.7392 (0.1222)	1.4160 (0.2341)	1.0900 (0.7641)	1.54515 (0.1008)	0.5660 (0.4518)	0.0029 (0.9564)

Notes: Figures in parenthesis are z-statistics. * and **- denote the significance at one and five percent level, respectiv
ARCH-LM is a Lagrange Multiplier test examines the null hypothesis of ARCH effects in the residuals (Engle, 1982).

Table 5.6 reveals the observed facts which uncover the GARCH outcomes across all commodity markets and confirm that the outcomes are numerically noteworthy, thereby indicating the presence of persistence degree of volatility with respect to both spot as well as futures market returns of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively. The outcome indicates that after occurrence of shock in the

futures and spot market of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL respectively, volatility persists in the market for a considerable greater period of time.

The leverage effect parameters are found to be significant statistically for futures and spot markets MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL respectively, specifying the presence of leverage effect. It also becomes obvious that negative shock effects of conditional volatility impacts the markets much more significantly as compared to positive shock effects of an identical magnitude a in MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively. This implies that negative shock effects create much more increased levels of volatility when compared to positive shocks of the identical magnitude.

Most importantly, the EGARCH result shows that the bidirectional spillover exists between the spot market and futures market in the case of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. Despite of bidirectional spillover exists among futures and spot market for all commodity markets, the spillover effect from futures to spot is more than that of spot to futures market. Therefore, the evidences from Bivariate EGARCH show that volatility spillover effect exists from futures to spot market for MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

To verify the effectiveness of Bivariate EGARCH outcomes with respect to MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, the outcomes imply the reasonableness and correctness of the Bivariate EGARCH model to emphasise the time varying volatility (ARCH) impacts in the scrutinised time series for MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL.

CHAPTER 6

PRICE DISCOVERY AND VOLATILITY SPILLOVER IN SPOT AND FUTURES PRICES OF INDIVIDUAL COMMODITIES IN THE INDIAN COMMODITY MARKET

6.1 Introduction:

This chapter investigates the price discovery and volatility spillover in individual commodities spot and futures prices in the commodity markets. The individual commodities considered for the study represent commodities traded at MCX and NCDEX belonging to Agriculture, Bullion, Energy and Metal sector.

The individual agricultural commodities are considered from NCDEX as it has the major market share in agricultural trading, whereas individual bullion, energy and metal commodities are considered from MCX as it has the major market share in the non agricultural commodities.

The study investigates whether individual spot or the futures commodity prices representing agriculture, bullion, energy and metal play a major role in the price discovery process. It evaluates whether there is unidirectional flow of information in the individual commodities from the futures prices to the spot prices, or spot prices to the futures prices or a bidirectional flow of information between the two. The results would help to identify the extent of relationship between the futures and spot prices and the speed of adjustments between the two. Further, the study evaluates whether the volatility spills over from the futures prices to the spot prices, or spot prices to the futures prices or a bidirectional flow of volatility between the two.

I. PRICE DISCOVERY

6.2 Descriptive Statistics:

To assess the distributional properties the results of descriptive statistics are presented in Table– 6.1 of spot and futures market returns of each individual commodities that belongs to Agriculture, Bullion, Energy and Metals in the Indian commodity market. The table result depicts that the futures markets provides relatively high returns than the spot markets in the case of majority of the underlying commodities of different sectors. The values of

standard deviation indicate that the volatility nature of all underlying commodities was found to be higher. Further, the table results reveal that the skewness statistics of futures and spot market returns of all commodities are significantly different from zero i.e. they are skewed either to the right or to the left. Also, the excess kurtosis values of all futures and spot return series of selected commodities are fat-tailed or leptokurtic compared to the normal distribution. In addition, the Jarque-Bera test statistics indicate that the null hypothesis of normality of return series of all selected commodities of different sectors had been rejected at one per cent significance level. Hence, it can be concluded that the futures and spot market return series of all selected commodities were significantly departed from normality.

Table- 6.1 Descriptive Statistics for Individual Commodity Markets Return

AGRICULTURE								
Statistics	**BARLEY**		**CASTOR SEEDS**		**CHANNA**		**CHILLI**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	0.000147	0.000144	0.000212	0.000205	0.000372	0.000409	0.000503	0.000557
Median	0.000000	0.000000	0.000426	0.000000	0.000000	0.000000	-0.000248	0.000000
Maximum	0.127101	0.375908	0.096977	0.092854	0.073901	0.142203	0.149730	0.383067
Minimum	-0.200631	-0.060106	-0.131498	-0.169188	-0.110673	-0.225420	-0.464837	-0.365148
Std. Dev.	0.011478	0.015876	0.015569	0.018601	0.013697	0.017915	0.018609	0.031438
Skewness	-2.289497	7.357336	-0.201958	-0.611565	-0.113825	-1.506670	-7.438834	1.518344
Kurtosis	65.11537	161.2237	12.36058	14.51608	7.333968	40.47377	229.2004	48.68950
Jarque-Bera Statistics	331355.7* (0.0000)	2156879* (0.0000)	4879.311* (0.0000)	7454.617* (0.0000)	1989.457* (0.0000)	149286.6* (0.0000)	3890496* (0.0000)	158741.6* (0.0000)
Statistics	**CORRIANDER**		**COTTON SEED OIL CAKE**		**COTTON**		**CRUDE PALM OIL**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	-8.72E-05	6.57E-05	0.000673	0.000645	-0.000509	-0.000512	2.92E-05	6.75E-05

Median	-0.000357	0.000000	0.000000	0.000000	0.000248	0.000000	0.000000	0.000000
Maximum	0.147061	0.126657	0.685932	0.712250	0.093782	0.092154	0.096012	0.224611
Minimum	-0.126495	-0.405623	-0.132138	-0.322127	-0.694954	-0.650243	-0.111343	-0.148973
Std. Dev.	0.017568	0.022824	0.019067	0.022518	0.029607	0.028547	0.009471	0.011096
Skewness	0.431657	-2.574697	18.30066	10.48515	-20.67276	-18.86487	-0.014641	7.543760
Kurtosis	10.50818	62.31304	652.9633	413.5195	486.8757	431.8172	18.74098	177.1337
Jarque-Bera Statistics	4136.305* (0.0000)	256684.7* (0.0000)	45716562* (0.0000)	18227209* (0.0000)	6131973* (0.0000)	4818002* (0.0000)	32686.23* (0.0000)	4030078* (0.0000)

Statistics	**GAUR GUM**		**GAUR SEED**		**GAUR**		**JEERA**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	0.001294	0.001208	0.001338	0.001304	0.000432	0.000361	0.000273	0.000260
Median	0.000677	0.000000	0.000714	0.000000	0.000102	0.000000	-0.000443	-0.000541
Maximum	0.129549	0.229956	0.123798	0.155848	0.150953	0.180907	0.304416	0.180185
Minimum	-0.210441	-0.246517	-0.198615	-0.238681	-0.131239	-0.156295	-0.303198	-0.058108
Std. Dev.	0.019013	0.021173	0.017861	0.020930	0.012322	0.014741	0.011655	0.017339
Skewness	-0.454200	0.124792	-0.303406	0.082681	1.937715	2.347033	0.602291	1.502966
Kurtosis	14.55982	18.38854	16.87416	14.34063	49.17953	52.35873	333.0827	13.88475
Jarque-Bera Statistics	12902.04* (0.0000)	22729.59* (0.0000)	19077.12* (0.0000)	12724.36* (0.0000)	181201.0* (0.0000)	207420.6* (0.0000)	12720617* (0.0000)	14887.19* (0.0000)

Statistics	**KAPPAS**		**MAIZE**		**MENTA OIL**		**MUSTARD OIL**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	0.000973	0.000907	0.000463	0.000422	0.000617	0.000507	0.000149	0.000201
Median	0.000000	0.000000	0.000264	0.000000	0.000000	0.000000	0.000336	0.000000
Maximum	0.653652	0.613334	0.925259	0.173472	0.117783	0.261727	0.055188	0.073427
Minimum	-0.199551	-0.237344	-0.820005	-0.127367	-0.097704	-0.158089	-0.080054	-0.097651
Std. Dev.	0.035266	0.039774	0.027115	0.015603	0.018129	0.022274	0.008334	0.011078
Skewness	11.81414	8.271352	5.249584	1.519208	0.137781	1.528942	-0.717903	-0.239788
Kurtosis	221.3325	124.9710	963.3500	29.52930	9.390761	24.49995	13.52143	14.49228
Jarque-Bera Statistics	1097173* (0.0000)	344676* (0.0000)	87511023* (0.0000)	67649.27* (0.0000)	2603.392* (0.0000)	30005.45* (0.0000)	5647.500* (0.0000)	6626.155* (0.0000)

Statistics	PEAS		PEPPER		POTATO		SOYA BEAN	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	0.000215	0.000350	0.000656	0.000614	0.000203	0.000219	0.000235	0.000239
Median	0.000000	0.000000	0.000409	0.000000	0.000000	0.000000	0.000687	0.000000
Maximum	0.078837	0.136990	0.072264	0.177860	0.882963	0.660759	0.050415	0.101530
Minimum	-0.047318	-0.139991	-0.079550	-0.135291	-0.821862	-0.854467	-0.241747	-0.356975
Std. Dev.	0.009095	0.014436	0.010641	0.018076	0.041331	0.045291	0.012519	0.015429
Skewness	1.709477	0.892848	0.266767	1.090839	2.037062	-2.801604	-3.924597	-5.184907
Kurtosis	15.17846	26.42032	8.491459	14.41921	388.0435	193.9981	63.47990	112.4495
Jarque-Bera Statistics	8586.888* (0.0000)	29607.91* (0.0000)	3071.982* (0.0000)	13639.71* (0.0000)	5819797* (0.0000)	1433083* (0.0000)	494219.0* (0.0000)	1606024.0* (0.0000)

Statistics	SOYA OIL		SUGAR		TURMERIC		WHEAT	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	0.000199	0.000169	0.000542	0.000516	0.000464	0.000504	0.000277	0.000277
Median	0.000000	6.79E-05	-0.000269	-0.000312	-0.000249	0.000000	0.000163	0.000000
Maximum	0.043940	0.070847	0.090891	0.136237	0.113659	0.307272	0.082875	0.109217
Minimum	-0.287954	-0.275372	-0.185469	-0.115333	-0.132067	-0.408631	-0.120136	-0.230258
Std. Dev.	0.009865	0.012137	0.009926	0.012927	0.015435	0.027946	0.008923	0.012929
Skewness	-9.618855	-5.296447	-2.849191	2.867056	0.782228	-0.764520	-1.382985	-3.360915
Kurtosis	290.3312	116.4309	94.05343	35.07600	14.35589	52.55651	32.37638	78.81620
Jarque-Bera Statistics	8776683* (0.0000)	1373587* (0.0000)	518812.7* (0.0000)	66182.40* (0.0000)	12089.14* (0.0000)	226153.1* (0.0000)	76433.41* (0.0000)	508601.6* (0.0000)

Statistics	RUBBER		BULLION					
			GOLD		PLATINUM		SILVER	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	0.000250	0.000232	0.000444	0.000445	-0.002200	-0.002205	0.000286	0.000266
Median	0.000541	0.000000	0.000503	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.078343	0.492414	0.250782	0.260914	0.079223	0.056217	0.435649	0.519346

Minimum	-0.674351	-0.568947	-0.363402	-0.348915	-2.351645	-2.281544	-0.573980	-0.557585
Std. Dev.	0.019003	0.024021	0.049546	0.049815	0.073573	0.071075	0.077929	0.080420
Skewness	-26.49532	0.368938	-1.374156	-1.122864	-30.36426	-30.75293	-0.736416	-0.383058
Kurtosis	941.3759	344.9129	13.90449	13.76501	970.0881	986.6752	12.33100	11.64667
Jarque-Bera Statistics	62239880* (0.0000)	8236931* (0.0000)	11887.34* (0.0000)	11367.30* (0.0000)	42017895* (0.0000)	43470141* (0.0000)	8473.786* (0.0000)	7155.291* (0.0000)

ENERGY

Statistics	**ATF**		**BRENT CRUDE OIL**		**CRUDE OIL**		**FURNACE OIL**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	0.000622	0.000718	4.75E-05	0.000145	4.43E-05	2.85E-05	0.001025	0.000948
Median	0.000000	0.000000	0.000000	0.000000	0.000000	0.000556	0.000593	0.000000
Maximum	2.268480	0.216300	0.910414	0.748355	0.867850	0.784060	1.790575	0.607684
Minimum	-2.266670	-0.406856	-0.570609	-0.536594	-0.787579	-0.678993	-1.806399	-0.541136
Std. Dev.	0.121168	0.061650	0.091823	0.084395	0.098735	0.090573	0.154609	0.116466
Skewness	-0.122180	-1.185861	0.831530	0.316502	-0.402513	-0.207006	-0.280623	-0.507607
Kurtosis	250.8084	9.612024	21.10554	18.85791	17.79619	17.74561	59.36468	12.73148
Jarque-Bera Statistics	2515213* (0.0000)	2021.045* (0.0000)	25137.59* (0.0000)	19152.92* (0.0000)	20694.97* (0.0000)	20509.23* (0.0000)	88567.01* (0.0000)	2668.541* (0.0000)

Statistics	**GASOLINE**		**HEATING OIL**		**NATURAL GAS**		**METAL** **ALUMINIUM**	
	Spot Returns	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**	**Spot Returns**	**Futures Returns**
Mean	0.000527	0.000433	0.000731	0.000743	-0.000245	-0.000268	-5.29E-05	-4.00E-05
Median	0.000000	0.000000	0.000000	0.000000	0.000000	-0.001128	0.000000	0.000000
Maximum	0.250211	0.259669	0.312007	0.313992	0.635653	0.526283	0.122538	0.080417
Minimum	-0.331511	-0.309203	-0.420708	-0.419049	-0.652632	-0.620186	-0.318960	-0.332048
Std. Dev.	0.059631	0.059761	0.068562	0.063671	0.108593	0.098434	0.014229	0.016308
Skewness	0.109227	-0.251091	-1.313943	-1.493195	0.037039	-0.220479	-4.820240	-3.288362
Kurtosis	6.457649	6.355962	10.99472	13.08403	10.22586	9.724285	116.9211	78.01704
Jarque-Bera Statistics	427.6090* (0.0000)	410.2099* (0.0000)	2883.021* (0.0000)	4502.591* (0.0000)	4939.005* (0.0000)	4295.072* (0.0000)	1260803* (0.0000)	546996.9* (0.0000)

Statistics	COPPER		IRON ORE		LEAD		NICKEL	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	0.000129	0.000107	-2.84E-05	-0.000409	0.000165	0.000159	-0.000283	-0.000324
Median	0.000000	0.000124	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.100096	0.089850	0.127389	0.078435	0.240596	0.106160	0.281468	0.172761
Minimum	-0.135687	-0.108812	-0.107258	-0.075707	-0.114564	-0.128827	-0.158959	-0.146850
Std. Dev.	0.018247	0.015659	0.015091	0.014469	0.022294	0.018945	0.021450	0.019150
Skewness	-0.251598	-0.300630	1.338497	-0.407355	0.347140	-0.377652	0.444465	-0.061068
Kurtosis	7.996697	8.961293	21.41105	10.58368	11.77955	9.412074	21.57245	11.58356
Jarque-Bera Statistics	2388.562* (0.0000)	3399.890* (0.0000)	7946.635* (0.0000)	1335.624* (0.0000)	7358.750* (0.0000)	3954.881* (0.0000)	36387.67* (0.0000)	7756.126* (0.0000)

Statistics	SPONGE IRON		STEEL FLAT		THERMAL COAL		TIN	
	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns	Spot Returns	Futures Returns
Mean	2.63E-05	7.18E-05	0.000123	0.000130	0.000446	0.000480	0.000475	0.000472
Median	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.172930	0.185633	0.039701	0.050867	0.198092	0.181886	0.285798	0.116782
Minimum	-0.103684	-0.158437	-0.045715	-0.079203	-0.212587	-0.172371	-0.131652	-0.136142
Std. Dev.	0.016836	0.017874	0.008109	0.010122	0.047294	0.041804	0.022239	0.015182
Skewness	1.101847	-1.060048	0.257799	-1.600397	0.002041	0.175142	0.994868	0.100871
Kurtosis	26.30547	48.11952	9.517591	18.22217	7.414678	6.946093	24.02675	13.32082
Jarque-Bera Statistics	14065.36* (0.0000)	52366.83* (0.0000)	1072.183* (0.0000)	6069.151* (0.0000)	681.3168* (0.0000)	548.6481* (0.0000)	28289.10* (0.0000)	6757.679* (0.0000)

Statistics	ZINC	
	Spot Returns	Futures Returns
Mean	-0.000162	-0.000197
Median	0.000000	0.000000
Maximum	0.129644	0.157603
Minimum	-0.156335	-0.120429

Std. Dev.	0.018257	0.017702
Skewness	-0.301530	0.128353
Kurtosis	8.797312	8.575944
Jarque-Bera Statistics	3564.282* (0.0000)	3268.894* (0.0000)

6.3 Unit Root Test:

The unit root property of the data series is crucial for the cointegration and causality analyses. For each of the individual commodities future and spot prices stationarity can be checked by using Phillips-Perron and Augmented Dickey-Fuller tests. The unit root test outcomes obtained through both the tests evidence the stationary nature of the price series at their first difference for each of the commodities. This in turn implies that each commodities future and spot prices are stationary and integrated at order one.

Table- 6.2 Results of Unit Root Test

Name of the Commodity	Market	Augmented Dickey-Fuller Test Statistics		Phillips-Perron Test Statistics	
		Level	First Difference	Level	First Difference
AGRICULTURE					
BARLEY	*Spot*	-1.69	-42.98*	-1.82	-43.28*
	Futures	-2.08	-43.90*	-2.10	-44.00*
CASTOR SEEDS	*Spot*	-2.38	-26.49*	-2.39	-30.33*
	Futures	-2.70	-32.38*	-2.67	-32.27*
CHANNA	*Spot*	-1.98	-35.71*	-2.01	-45.67*
	Futures	-2.29	-49.95*	-2.42	-50.14*
CHILLI	*Spot*	-2.17	-33.46*	-2.18	-33.32*
	Futures	-2.56	-39.98*	-2.40	-40.03*
CORRIANDER	*Spot*	-1.33	-34.67*	-1.57	-35.55*
	Futures	-1.29	-37.01*	-1.83	-38.03*
COTTON SEED OIL CAKE	*Spot*	-1.26	-47.60*	-1.35	-48.05*
	Futures	-1.23	-51.17*	-1.27	-51.13*
COTTON	*Spot*	-0.87	-25.36*	-0.85	-25.36*
	Futures	-0.80	-24.94*	-0.80	-24.94*
CRUDE PALM OIL	*Spot*	-1.89	-31.23*	-2.12	-48.73*
	Futures	-1.31	-55.96*	-1.33	-55.97*
GAUR GUM	*Spot*	-2.81	-42.91*	-0.42	-42.73*
	Futures	-2.75	-42.90*	-0.44	-42.78*
	Spot	-0.96	-31.48*	1.44	-32.08*

GAUR SEED	*Futures*	-1.00	-32.42*	1.48	-31.09*
GAUR	*Spot*	-2.18	-45.54*	0.35	-46.18*
	Futures	-2.21	-42.55*	0.34	-43.22*
JEERA	*Spot*	-1.26	-32.76*	0.96	-31.22*
	Futures	-1.27	-37.77*	0.94	-35.20*
KAPAS	*Spot*	-2.84	-27.76*	0.02	-22.76*
	Futures	-2.80	-23.83*	0.02	-27.72*
MAIZE	*Spot*	-2.69	-41.70*	-0.01	-42.34*
	Futures	-2.65	-42.66*	-0.02	-40.63*
MENTA OIL	*Spot*	-1.62	-31.53*	0.26	-31.66*
	Futures	-1.64	-31.59*	0.23	-29.69*
MUSTARD OIL	*Spot*	-1.61	-42.72*	1.51	-41.60*
	Futures	-1.64	-32.69*	1.53	-36.62*
PEAS	*Spot*	-2.01	-31.71*	0.93	-37.94*
	Futures	-2.06	-41.68*	0.98	-42.80*
PEPPER	*Spot*	-1.87	-51.92*	-0.17	-55.73*
	Futures	-1.77	-54.86*	-0.26	-53.89*
POTATO	*Spot*	-1.42	-33.78*	0.04	-37.48*
	Futures	-1.47	-32.82*	0.02	-39.53*
RUBBER	*Spot*	-2.02	-29.87*	0.56	-28.05*
	Futures	-2.01	-24.84*	0.55	-26.17*
SOYA BEAN	*Spot*	-1.96	-45.23*	0.90	-42.97*
	Futures	-1.97	-42.26*	0.89	-41.98*
SOYA OIL	*Spot*	-1.57	-33.25*	1.04	-32.53*
	Futures	-1.58	-32.29*	1.00	-31.54*
SUGAR	*Spot*	-2.37	-31.39*	-2.36	-31.88*
	Futures	-2.49	-38.34*	-2.45	-38.44*
TURMERIC	*Spot*	-0.75	-35.20*	-0.95	-38.04*
	Futures	-1.24	-45.87*	-1.33	-45.96*
WHEAT	*Spot*	-1.46	-37.80*	-1.50	-38.07*
	Futures	-2.30	-46.54*	-2.29	-46.55*
BULLION					
GOLD	*Spot*	-2.08	-21.03*	-2.30	-48.71*
	Futures	-1.92	-12.66*	-2.12	-10.51*
PLATINUM	*Spot*	-1.92	-12.16*	0.31	-11.17*
	Futures	-2.18	-22.50*	0.25	-23.06*
SILVER	*Spot*	-2.00	-22.01*	-0.42	-25.14*
	Futures	-2.48	-20.47*	-0.37	-21.42*
ENERGY					
ATF	*Spot*	-1.66	-17.37*	-0.66	-17.93*
	Futures	-1.78	-17.53*	-1.95	-15.73*
BRENT CRUDE OIL	*Spot*	-1.90	-13.83*	-1.59	-14.90*
	Futures	-1.85	-13.71*	-1.32	-16.32*
CRUDE OIL	*Spot*	-2.17	-32.26*	0.20	-32.09*
	Futures	-2.19	-42.27*	0.19	-42.10*
FURNACE OIL	*Spot*	-1.13	-22.38*	-0.39	-21.12*
	Futures	-1.15	-32.39*	-0.40	-31.13*
GASOLINE	*Spot*	-2.21	-42.42*	0.77	-42.40*
	Futures	-2.22	-32.44*	0.76	-32.39*

HEATING OIL	*Spot*	-1.25	-12.03*	-0.73	-11.27*
	Futures	-1.27	-13.06*	-0.73	-10.28*
NATURAL GAS	*Spot*	-0.50	-12.03*	-1.00	-10.58*
	Futures	-0.50	-15.05*	-0.99	-16.59*
METAL					
ALUMINIUM	*Spot*	-1.90	-43.21*	-1.04	-43.37*
	Futures	-1.23	-42.63*	-1.19	-46.70*
COPPER	*Spot*	-1.73	-51.92*	-1.77	-51.87*
	Futures	-1.62	-47.17*	-1.71	-47.85*
IRON ORE	*Spot*	-1.58	-31.84*	0.21	-31.54*
	Futures	-1.48	-31.72*	0.25	-31.56*
LEAD	*Spot*	-2.06	-32.10*	0.42	-32.09*
	Futures	-2.10	-22.14*	0.40	-22.14*
NICKLE	*Spot*	-0.94	-22.32*	-0.58	-21.01*
	Futures	-1.02	-42.45*	-0.52	-41.04*
SPONGE IRON	*Spot*	-2.40	-41.40*	0.60	-42.52*
	Futures	-2.38	-41.54*	0.50	-42.50*
STEEL FLAT	*Spot*	-21.81	-3.08*	-0.30	-21.87*
	Futures	-21.96	-3.07*	-0.29	-21.75*
THERMAL COAL	*Spot*	-0.66	-41.71*	-0.68	-40.77*
	Futures	-0.64	-41.66*	-0.69	-40.76*
TIN	*Spot*	-2.05	-32.21*	-0.35	-32.08*
	Futures	-2.10	-22.26*	-0.36	-22.13*
ZINC	*Spot*	-1.52	-53.27*	-0.45	-51.50*
	Futures	-1.40	-53.10*	-0.43	-51.27*

Notes: * – indicates significance at one per cent level. Optimal lag length is determined by the Schwarz Information Criterion (SIC) and Newey-West Criterion for the Augmented Dickey-Fuller Test and Phillips-Perron Test respectively.

6.4 Johensen Cointegration Test:

Cointegration test is sensitive to the selection of optimal lag length, and the necessary lag length of futures and spot price series of respective commodities was chosen on the basis of Schwarz Information Criteria (SIC) and it revealed optimal lag of one and two for the 45 underlying commodities respectively. **(Refer Annexure 2- Results of VAR Lag Length Selection)**

Table- 6.3 Results of Johansen's Cointegration Test

Name of the Stocks	vector (*r*)	Trace Statistics (λ_{trace})	5 % critical value for λ_{trace} test	Max-Eigen Statistics (λ_{max})	5 % critical value for λ_{max} test	Remarks
AGRICULTURE						
BARLEY	H_0: r = 0**	17.93684	15.49471	15.595740	14.26460	*Cointegrated*
	H_1: r ≥ 1	3.341105	3.841466	3.341105	3.841466	
CASTOR SEEDS	H_0: r = 0**	32.66270	15.49471	26.30692	14.26460	*Cointegrated*
	H_1: r ≥ 1	3.355777	3.841466	3.355777	3.841466	
CHANNA	H_0: r = 0**	35.11332	25.87211	29.37391	19.38704	*Cointegrated*
	H_1: r ≥ 1	5.739407	12.51798	5.739407	12.51798	
CHILLI	H_0: r = 0**	59.55279	25.87211	48.91235	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.64044	12.51798	10.64044	12.51798	
CORRIANDER	H_0: r = 0**	46.74926	25.87211	33.63859	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.11067	12.51798	10.11067	12.51798	
COTTON SEED OIL CAKE	H_0: r = 0**	55.42249	25.87211	47.67519	19.38704	*Cointegrated*
	H_1: r ≥ 1	7.747305	12.51798	7.747305	12.51798	
COTTON	H_0: r = 0**	40.45552	25.87211	36.89043	19.38704	*Cointegrated*
	H_1: r ≥ 1	3.565089	12.51798	3.565089	12.51798	
CRUDE PALM OIL	H_0: r = 0**	27.52888	25.87211	20.43713	19.38704	*Cointegrated*
	H_1: r ≥ 1	4.091758	12.51798	4.091758	12.51798	
GAUR GUM	H_0: r = 0**	127.8062	25.87211	89.51513	19.38704	*Cointegrated*
	H_1: r ≥ 1	8.29105	12.51798	8.29105	12.51798	
GAUR SEED	H_0: r = 0**	118.4934	25.87211	86.73486	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.75856	12.51798	11.75856	12.51798	
GAUR	H_0: r = 0**	44.88531	25.87211	35.17063	19.38704	*Cointegrated*
	H_1: r ≥ 1	9.714681	12.51798	9.714681	12.51798	
JEERA	H_0: r = 0**	149.3891	25.87211	143.3701	19.38704	*Cointegrated*
	H_1: r ≥ 1	6.019044	12.51798	6.019044	12.51798	
KAPAS	H_0: r = 0**	52.53365	25.87211	48.26491	19.38704	*Cointegrated*
	H_1: r ≥ 1	4.268740	12.51798	4.268740	12.51798	
MAIZE	H_0: r = 0**	32.51206	25.87211	24.88586	19.38704	*Cointegrated*
	H_1: r ≥ 1	7.626195	12.51798	7.626195	12.51798	
MENTA OIL	H_0: r = 0**	29.7367	25.87211	22.8722	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.042	12.51798	10.51734	12.51798	
MUSTARD OIL	H_0: r = 0**	19.99053	25.87211	20.53730	19.38704	*Cointegrated*
	H_1: r ≥ 1	1.453231	12.51798	5.453231	12.51798	
PEAS	H_0: r = 0**	39.99053	25.87211	34.53730	19.38704	*Cointegrated*
	H_1: r ≥ 1	5.453231	12.51798	5.453231	12.51798	
PEPPER	H_0: r = 0**	149.0491	25.87211	143.2321	19.38704	*Cointegrated*
	H_1: r ≥ 1	5.817050	12.51798	5.817050	12.51798	
POTATO	H_0: r = 0**	28.7821	25.87211	22.0137	19.38704	*Cointegrated*
	H_1: r ≥ 1	6.768447	12.51798	6.768447	12.51798	
RUBBER	H_0: r = 0**	27.5934	25.87211	20.5756	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.18856	12.51798	10.6785	12.51798	
SOYA BEAN	H_0: r = 0**	67.504	25.87211	22.3577	19.38704	*Cointegrated*
	H_1: r ≥ 1	0.74143	12.51798	11.4576	12.51798	
SOYA OIL	H_0: r = 0**	49.7934	25.87211	23.7843	19.38704	*Cointegrated*
	H_1: r ≥ 1	1.08465	12.51798	10.7853	12.51798	
SUGAR	H_0: r = 0**	30.8967	25.87211	24.2545	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.28476	12.51798	9.2578	12.51798	
TURMERIC	H_0: r = 0**	30.9861	25.87211	20.45789	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.10189	12.51798	11.34768	12.51798	
	H_0: r = 0**	29.01323	25.87211	26.6433	19.38704	*Cointegrated*

WHEAT	H_1: r ≥ 1	11.18645	12.51798	11.1246	12.51798	
BULLION						
GOLD	H_0: r = 0**	25.95017	25.87211	212.5175	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.43257	12.51798	11.43257	12.51798	
PLATINUM	H_0: r = 0**	38.91139	25.87211	122.1003	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.01361	12.51798	11.01361	12.51798	
SILVER	H_0: r = 0**	73.3856	25.87211	25.8722	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.12467	12.51798	10.51745	12.51798	
ENERGY						
ATF	H_0: r = 0**	27.6984	25.87211	21.76893	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.2451	12.51798	9.34678	12.51798	
BRENT CRUDE OIL	H_0: r = 0**	27.0587	25.87211	51.4872	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.57154	12.51798	11.57154	12.51798	
CRUDE OIL	H_0: r = 0**	27.7875	25.87211	32.34578	19.38704	*Cointegrated*
	H_1: r ≥ 1	9.23969	12.51798	8.38964	12.51798	
FURNACE OIL	H_0: r = 0**	30.6399	25.87211	43.3489	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.27340	12.51798	7.2578	12.51798	
GASOLINE	H_0: r = 0**	29.4539	25.87211	39.12446	19.38704	*Cointegrated*
	H_1: r ≥ 1	8.19458	12.51798	10.5378	12.51798	
HEATING OIL	H_0: r = 0**	28.34224	25.87211	29.37899	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.34846	12.51798	11.38991	12.51798	
NATURAL GAS	H_0: r = 0**	33.39126	25.87211	33.12789	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.3980	12.51798	5.48954	12.51798	
METAL						
ALUMINIUM	H_0: r = 0**	22.40712	25.87211	19.9024	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.10065	12.51798	15.10406	12.51798	
COPPER	H_0: r = 0**	28.10406	25.87211	31.16574	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.0134	12.51798	6.36882	12.51798	
IRON ORE	H_0: r = 0**	26.05457	25.87211	41.24788	19.38704	*Cointegrated*
	H_1: r ≥ 1	12.25790	12.51798	6.48892	12.51798	
LEAD	H_0: r = 0**	28.34039	25.87211	40.24765	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.34173	12.51798	7.36787	12.51798	
NICKLE	H_0: r = 0**	27.54033	25.87211	31.25673	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.12105	12.51798	10.4378	12.51798	
SPONGE IRON	H_0: r = 0**	28.56808	25.87211	25.2487	19.38704	*Cointegrated*
	H_1: r ≥ 1	6.78715	12.51798	11.247882	12.51798	
STEEL FLAT	H_0: r = 0**	28.5443	25.87211	21.27892	19.38704	*Cointegrated*
	H_1: r ≥ 1	11.83214	12.51798	7.27543	12.51798	
THERMAL COAL	H_0: r = 0**	28.3406	25.87211	19.4957	19.38704	*Cointegrated*
	H_1: r ≥ 1	4.84486	12.51798	4.84486	12.51798	
TIN	H_0: r = 0**	29.3286	25.87211	21.86543	19.38704	*Cointegrated*
	H_1: r ≥ 1	9.32997	12.51798	11.1368	12.51798	
ZINC	H_0: r = 0**	35.9497	25.87211	20.5525	19.38704	*Cointegrated*
	H_1: r ≥ 1	10.39727	12.51798	10.39727	12.51798	

Notes: ** – indicates significance at five per cent level. The significant of the statistics is based on 5 per cent critical values obtained from Johansen and Juselius (1990). r is the number of cointegrating vectors. H_0 represents the null hypothesis of presence of no cointegrating vector and H_1 represents the alternative hypothesis of presence of cointegrating vector.

Johansen's Cointegration test is done to examine the presence of long-run relationship between spot and future market prices of underlying commodities across the sectors and its results are presented in Table- 6.3. The table result of Johansen's maximum Eigen (λ_{max})

and Trace (λ_{trace}) statistics indicates the presence of one cointegrating vector between the futures and spot market prices at 5 % level in case of each selected individual commodities of different sector respectively.

In India the existence of an extended long run association linking future and spot prices for each commodity can be confirmed by using Johansen test of cointegration. The presence of extended long run association connecting both the markets has very significant consequences on traders who trade in the futures market. The detection of cointegration between the markets implies that even though there is no equilibrium between the two markets in the short term, any deviation that may occur will get corrected in the long term promptly during the process of arbitrage and the underlying market risk may be hedged to the greatest possible degree by hedgers taking up extended period positions.

6.5 Vector Error Correction Model (VECM):

In order to check whether short-run disequilibrium exists, Vector Auto Regression (VAR) based on VECM has been applied. Kroner and Sultan (1993) shows that if the spot and futures prices are cointegrated, there must be an error correction representation that includes both the short term dynamics and long term information. For the purpose, the causality between spot and futures prices for respective commodities was estimated by using the Vector Error Correction Model (VECM) and its result are depicted in Table- 6.4.

Table- 6.4 Test Results of Vector Error Correction Model

AGRICULTURE								
	BARLEY		**CASTERSEEDS**		**CHANNA**		**CHILLI**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.003633**	0.004489***	-0.013060	0.032870*	-0.009418*	0.012002*	-0.020367*	0.008768
	(0.00190)	(0.00264)	(0.00890)	(0.01113)	(0.00317)	(0.00433)	(0.00330)	(0.00582)
	[-1.91677]	[1.69952]	[-1.46755]	[2.95449]	[-2.97093]	[2.77380]	[-6.17537]	[1.50584]
ΔS_{t-1}	0.014016	0.019296	-0.036331	0.056454	-0.026130	-0.007070	0.192585*	0.062090
	(0.02312)	(0.03221)	(0.03303)	(0.04129)	(0.02096)	(0.02861)	(0.02337)	(0.04126)
	[0.60635]	[0.59905]	[-1.10010]	[1.36736]	[-1.24653]	[-0.24710]	[8.24041]	[1.50489]
ΔS_{t-2}	--	---	---	---	---	---	---	---
ΔF_{t-1}	0.083865*	0.028221	0.285171*	0.101022*	0.218828*	0.014652	0.061498*	0.059757***
	(0.01676)	(0.02335)	(0.02791)	(0.03490)	(0.01617)	(0.02208)	(0.01400)	(0.02472)
	[5.00512]	[1.20873]	[10.2161]	[2.89492]	[13.5298]	[0.66371]	[4.39150]	[2.41711]
ΔF_{t-2}	---	---	---	---	---	---	---	---
c	0.000133	0.000138	0.000165	0.000176	0.000300	0.000404	0.000367	0.000478
	(0.00025)	(0.00035)	(0.00040)	(0.00050)	(0.00026)	(0.00036)	(0.00042)	(0.00074)
	[0.52963]	[0.39340]	[0.40779]	[0.34917]	[1.14988]	[1.13472]	[0.87957]	[0.64951]
Inference	F↔S (LR) F→S (SR)		S→F (LR) F→S (SR)		F↔S (LR) F→S (SR)		F→S (LR) F→S (SR)	
	CORRIANDOR		**COTTON SEED OIL CAKE**		**COTTON**		**CRUDE PALM OIL**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.018267*	-0.002794	-0.021218*	0.007089***	-0.326935*	-0.188703***	-0.000445	0.008327*
	(0.00354)	(0.00479)	(0.00333)	(0.00397)	(0.10095)	(0.09850)	(0.00163)	(0.00194)
	[-5.16250]	[-0.58374]	[-6.37647]	[1.78656]	[-3.23870]	[-1.91573]	[-0.27359]	[4.28486]
ΔS_{t-1}	0.036346	0.100141*	0.057715*	0.086843*	-0.338874**	-0.117745	0.222663*	0.062399*
	(0.02751)	(0.03722)	(0.01960)	(0.02337)	(0.16683)	(0.16279)	(0.01809)	(0.02160)
	[1.32114]	[2.69087]	[2.94466]	[3.71575]	[-2.03123]	[-0.72329]	[12.3102]	[2.88847]
ΔS_{t-2}	---	---	---	---	---	---	---	---

ΔF_{t-1}	0.181049* (0.02132) [8.49009]	0.070858** (0.02885) [2.45640]	0.056813* (0.01677) [3.38810]	-0.009958 (0.02000) [-0.49800]	0.349129** (0.17318) [2.01597]	0.113001 (0.16899) [0.66869]	-0.028802*** (0.01540) [-1.87065]	-0.008647 (0.01839) [-0.47020]
ΔF_{t-2}	---	---	---	---	---	---	---	---
c	-7.84E-05 (0.00040) [-0.19521]	6.79E-05 (0.00054) [0.12503]	0.000589 (0.00037) [1.59132]	0.000574 (0.00044) [1.30067]	-0.000496 (0.00117) [-0.42353]	-0.000498 (0.00114) [-0.43579]	2.35E-05 (0.00016) [0.14265]	6.57E-05 (0.00020) [0.33459]
Inference	F→S (LR) F↔S (SR)		F↔S (LR) F↔S (SR)		F↔S (LR) F→S (SR)		F→S (LR) F↔S (SR)	
	GAUR GUM		**GAUR SEED**		**GAUR**		**JEERA**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	*-0.047937** (0.01263) [-3.79592]	*0.052626** (0.01484) [3.54619]	*-0.039523** (0.01083) [-3.64929]	*0.050352** (0.01334) [3.77528]	*-0.019125** (0.00325) [-5.88120]	*-0.002244* (0.00407) [-0.55124]	-0.049154* (0.00475) [-10.3527]	0.012576 (0.00783) [1.60552]
ΔS_{t-1}	-0.163703* (0.02693) [-6.07903]	0.104652* (0.03164) [3.30711]	-0.118731* (0.02586) [-4.59103]	0.130008* (0.03185) [4.08223]	0.176650* (0.02272) [7.77664]	0.007434 (0.02844) [0.26139]	-0.338678* (0.01990) [-17.0220]	0.006839 (0.03282) [0.20834]
ΔS_{t-2}	---	---	---	---	0.012766 (0.02227) [0.57309]	-0.009210 (0.02789) [-0.33025]	-0.089608* (0.01926) [-4.65151]	0.020911 (0.03178) [0.65794]
ΔF_{t-1}	0.371126* (0.02458) [15.1015]	0.063604** (0.02888) [2.20245]	0.324066* (0.02260) [14.3362]	0.042427 (0.02784) [1.52414]	0.109108* (0.01853) [5.88915]	0.003183 (0.02320) [0.13722]	0.231172* (0.01279) [18.0737]	0.079282* (0.02110) [3.75715]
ΔF_{t-2}	---	---	---	---	0.019977 (0.01864) [1.07179]	-0.000460 (0.02334) [-0.01970]	0.078219* (0.01339) [5.84292]	-0.015954 (0.02209) [-0.72238]
c	0.001074* (0.00037) [2.89255]	0.001033** (0.00044) [2.36932]	0.001080* (0.00035) [3.12201]	0.001081* (0.00043) [2.53890]	0.000298 (0.00026) [1.13370]	0.000361 (0.00033) [1.09940]	0.000311 (0.00020) [1.56859]	0.000237 (0.00033) [0.72565]

Inference	F↔S (LR) F↔S (SR)		F↔S (LR) F↔S (SR)		F→S (LR) F→S (SR)		F→S (LR) F→S (SR)	
	KAPAS		**MAIZE**		**MENTA OIL**		**MUSTARD OIL**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.030500	0.138614*	0.000256**	-0.000312*	-0.024240*	0.016802	-0.007313*	0.003382
	(0.03235)	(0.03614)	(0.00012)	(6.8E-05)	(0.00818)	(0.01022)	(0.00301)	(0.00438)
	[-0.94278]	[3.83561]	[2.15310]	[-4.57170]	[-2.96398]	[1.64365]	[-2.43093]	[0.77260]
ΔS_{t-1}	0.007424	-0.050355	0.002983	0.003586	-0.010803	0.161217*	0.167996*	0.038029
	(0.06588)	(0.07359)	(0.02099)	(0.01204)	(0.03268)	(0.04085)	(0.03245)	(0.04721)
	[0.11269]	[-0.68422]	[0.14212]	[0.29788]	[-0.33058]	[3.94691]	[5.17787]	[0.80561]
ΔS_{t-2}					-0.050410	0.044097	0.008909	-0.047746
	---	---	---	---	(0.03204)	(0.04005)	(0.02953)	(0.04297)
					[-1.57332]	[1.10108]	[0.30167]	[-1.11119]
ΔF_{t-1}	0.076624***	0.122493***	0.019577***	0.010890	0.199359*	0.062704***	0.221078*	-0.022260
	(0.02929)	(0.06624)	(0.01660)	(0.02099)	(0.02644)	(0.03305)	(0.02254)	(0.03279)
	[1.69226]	[1.84933]	[1.73492]	[0.51881]	[7.53975]	[1.89727]	[9.80906]	[-0.67883]
ΔF_{t-2}					-0.006187	-0.048563	-0.009948	0.015093
	---	---	---	---	(0.02667)	(0.03333)	(0.02320)	(0.03376)
					[-0.23198]	[-1.45681]	[-0.42872]	[0.44708]
c	0.000891	0.000872	0.000446	0.000417	0.000557	0.000371	8.92E-05	0.000194
	(0.00151)	(0.00168)	(0.00057)	(0.00033)	(0.00045)	(0.00056)	(0.00022)	(0.00032)
	[0.59059]	[0.51789]	[0.78390]	[1.27799]	[1.23847]	[0.65866]	[0.40528]	[0.60608]
Inference	S→F (LR) F→S (SR)		F↔S (LR) F→S (SR)		F→S (LR) F→S (SR)		F→S (LR) F→S (SR)	
	PEAS		**PEPPER**		**POTATO**		**RUBBER**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.004085	0.035375*	-0.030299*	0.000956	-0.041984*	-0.012426	0.003422	0.018477*
	(0.00522)	(0.00805)	(0.00459)	(0.00902)	(0.00907)	(0.01005)	(0.00371)	(0.00470)

	[-0.78320]	[4.39374]	[-6.60539]	[0.10590]	[-4.62826]	[-1.23691]	[0.92168]	[3.93498]
ΔS_{t-1}	0.092542* (0.02847) [3.25055]	0.327420* (0.04395) [7.45055]	-0.091972* (0.02447) [-3.75781]	-0.037463 (0.04815) [-0.77806]	0.061640 (0.04089) [1.50762]	0.071634** (0.04528) [1.68202]	0.117500* (0.02904) [4.04594]	0.071020** (0.03673) [1.93378]
ΔS_{t-2}	--- 	--- 	0.092488* (0.02079) [4.44888]	0.028675 (0.04090) [0.70113]	--- 	--- 	--- 	---
ΔF_{t-1}	0.051291* (0.01791) [2.86344]	-0.128779* (0.02765) [-4.65756]	0.288815* (0.01303) [22.1652]	0.057084* (0.02563) [2.22692]	-0.015884 (0.03772) [-0.42106]	-0.029407 (0.04178) [-0.70387]	0.008344 (0.02292) [0.36401]	0.027377 (0.02899) [0.94445]
ΔF_{t-2}	--- 	--- 	0.005113 (0.01399) [0.36540]	-0.020090 (0.02753) [-0.72975]	--- 	--- 	--- 	---
c	0.000184 (0.00025) [0.73273]	0.000340 (0.00039) [0.87505]	0.000474** (0.00019) [2.53031]	0.000596 (0.00037) [1.61670]	0.000188 (0.00133) [0.14104]	0.000175 (0.00148) [0.11829]	0.000222 (0.00046) [0.48271]	0.000208 (0.00058) [0.35830]
Inference	S→F (LR) F↔S (SR)		F→S (LR) F→S (SR)		F→S (LR) S→F (SR)		S→F (LR) S→F (SR)	
	SOYA BEAN		**SOYA OIL**		**SUGAR**		**TURMERIC**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.024589* (0.00318) [-7.73848]	-0.000738 (0.00414) [-0.17834]	-0.028620* (0.00636) [-4.50212]	0.009878 (0.00816) [1.20997]	-0.018129* (0.00703) [-2.57747]	0.043984* (0.00945) [4.65566]	-0.011606* (0.00303) [-3.82690]	0.018855* (0.00579) [3.25795]
ΔS_{t-1}	0.136330* (0.01935) [7.04536]	0.063404** (0.02519) [2.51671]	-0.005381 (0.02582) [-0.20838]	0.034621 (0.03316) [1.04398]	0.130558* (0.02832) [4.60992]	-0.048348 (0.03804) [-1.27103]	0.191304* (0.02401) [7.96926]	0.083969** (0.04581) [1.83293]
ΔS_{t-2}	0.022609 (0.01855) [1.21888]	-0.001580 (0.02415) [-0.06543]	-0.033235 (0.02441) [-1.36166]	-0.045572 (0.03134) [-1.45393]	-0.004392 (0.02740) [-0.16025]	0.062056** (0.03681)	0.043727*** (0.02313) [1.89084]	0.008698 (0.04413) [0.19708]

						[1.68597]		
ΔF_{t-1}	0.152716*	-0.003569	0.213336*	0.030314	0.136205*	0.040478	0.082640*	0.014702
	(0.01526)	(0.01986)	(0.02052)	(0.02635)	(0.02121)	(0.02848)	(0.01276)	(0.02436)
	[10.0093]	[-0.17969]	[10.3956]	[1.15029]	[6.42243]	[1.42104]	[6.47543]	[0.60366]
ΔF_{t-2}	-0.016494	0.020651	0.047955*	0.051286***	0.029292	0.042136	-0.004510	0.012771
	(0.01543)	(0.02009)	(0.02074)	(0.02663)	(0.02135)	(0.02868)	(0.01278)	(0.02439)
	[-1.06864]	[1.02766]	[2.31271]	[1.92601]	[1.37193]	[1.46933]	[-0.35294]	[0.52371]
c	0.000164	0.000221	0.000169	0.000164	0.000379	0.000452	0.000315	0.000452
	(0.00021)	(0.00027)	(0.00019)	(0.00024)	(0.00025)	(0.00033)	(0.00031)	(0.00059)
	[0.78245]	[0.80929]	[0.90000]	[0.68180]	[1.53001]	[1.35972]	[1.01214]	[0.75993]
Inference	F→S (LR) S→F (SR)		F→S (LR) F→S (SR)		F↔S (LR) F↔S (SR)		F↔S (LR) F↔S (SR)	
	WHEAT		**BULLION**					
			GOLD		**PLATINUM**		**SILVER**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.017700*	0.006699	-0.150223*	0.109412**	-0.225787**	0.040903	-0.201649*	0.195496*
	(0.00323)	(0.00485)	(0.05605)	(0.05646)	(0.10236)	(0.09900)	(0.07275)	(0.07549)
	[-5.47337]	[1.38069]	[-2.68036]	[1.93796]	[-2.20578]	[0.41316]	[-2.77183]	[2.58969]
ΔS_{t-1}	0.156399*	0.051943	-0.277300*	0.019886	0.045733	0.155665***	-0.339724*	-0.204806*
	(0.02224)	(0.03337)	(0.06567)	(0.06615)	(0.13211)	(0.09777)	(0.07654)	(0.07942)
	[7.03316]	[1.55681]	[-4.22282]	[0.30062]	[0.34617]	[1.71829]	[-4.43863]	[-2.57872]
ΔS_{t-2}	-0.042438**	-0.047271	---	---	---	---	---	---
	(0.02191)	(0.03287)						
	[-1.93716]	[-1.43810]						
ΔF_{t-1}	0.075277*	-0.017897	0.117030***	-0.194012*	-0.028281	-0.134879	0.209522*	0.068111
	(0.01516)	(0.02275)	(0.06506)	(0.06554)	(0.13555)	(0.13110)	(0.07471)	(0.07752)
	[4.96566]	[-0.78683]	[1.79868]	[-2.96010]	[-0.20864]	[-1.02885]	[2.80458]	[0.87860]
ΔF_{t-2}	0.041938*	-0.042865***	---	---	---	---	---	---
	(0.01521)							

	[2.75719]	(0.02282) [-1.87828]						
c	0.000203 (0.00019) [1.08158]	0.000287 (0.00028) [1.01856]	0.000542 (0.00102) [0.52906]	0.000549 (0.00103) [0.53203]	-0.002169 (0.00225) [-0.96584]	-0.002162 (0.00217) [-0.99563]	0.000314 (0.00161) [0.19547]	0.000298 (0.00167) [0.17831]
Inference	F→S (LR) F→S (SR)		F↔S (LR) F→S (SR)		F→S (LR) S→F (SR)		F↔S (LR) F↔S (SR)	
ENERGY								
	ATF		**BRENT CRUDE OIL**		**CRUDE OIL**		**FURNACE OIL**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.952413* (0.05692) [-16.7335]	0.023005 (0.03605) [0.63808]	-0.275997* (0.08502) [-3.24644]	0.159077** (0.07914) [2.00997]	-0.308855* (0.05771) [-5.35183]	0.090576*** (0.05281) [1.71508]	-0.870339* (0.10227) [-8.50991]	0.090589 (0.08534) [1.06147]
ΔS_{t-1}	-0.011528 (0.04069) [-0.28332]	-0.008891 (0.02577) [-0.34494]	-0.330122* (0.08081) [-4.08538]	-0.106223 (0.07523) [-1.41206]	-0.077604 (0.05622) [-1.38031]	0.128924** (0.05145) [2.50582]	-0.047836 (0.07306) [-0.65475]	-0.029823 (0.06096) [-0.48918]
ΔS_{t-2}	---	---	---	---	---	---	---	---
ΔF_{t-1}	-0.145773** (0.06285) [-2.31921]	-0.130957* (0.03981) [-3.28915]	0.261382* (0.08518) [3.06875]	0.007762 (0.07929) [0.09789]	0.001387 (0.06147) [0.02256]	-0.269146* (0.05625) [-4.78456]	-0.097849*** (0.08506) [-1.66030]	-0.118287*** (0.07098) [-1.66643]
ΔF_{t-2}	---	---	---	---	---	---	---	---
c	0.000971 (0.00308) [0.31553]	0.001003 (0.00195) [0.51450]	0.000177 (0.00212) [0.08363]	0.000210 (0.00197) [0.10666]	5.39E-05 (0.00205) [0.02625]	2.95E-05 (0.00188) [0.01571]	0.000912 (0.00536) [0.17013]	0.001030 (0.00447) [0.23032]
Inference	F→S (LR)		F→S (LR) F→S (SR)		F↔S (LR) S→F (SR)		F→S (LR) F→S (SR)	

	F→S (SR)							
	GASOLINE		**HEATING OIL**		**NATURAL GAS**		**METAL**	
							ALUMINIUM	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.129461	0.372317*	-0.255179**	0.244491*	-0.363894*	0.041922	-0.162764*	0.098189*
	(0.08668)	(0.08577)	(0.10022)	(0.09511)	(0.03559)	(0.03400)	(0.01939)	(0.02151)
	[-1.49355]	[4.34090]	[-2.54619]	[2.57064]	[-10.2235]	[1.23303]	[-8.39216]	[4.56501]
ΔS_{t-1}	-0.124912	0.045604	-0.321285*	-0.077195	-0.269561*	-0.084203**	-0.135979*	0.185504*
	(0.08179)	(0.08093)	(0.08727)	(0.08282)	(0.03459)	(0.03304)	(0.02423)	(0.02687)
	[-1.52719]	[0.56348]	[-3.68147]	[-0.93208]	[-7.79393]	[-2.54883]	[-5.61271]	[6.90426]
ΔS_{t-2}	---	---	---	---	---	---	---	---
ΔF_{t-1}	-0.129382***	-0.264693*	0.206942**	0.000566	0.202909*	-0.080668**	0.108149*	-0.354320*
	(0.08028)	(0.07943)	(0.09142)	(0.08676)	(0.03888)	(0.03714)	(0.02246)	(0.02491)
	[-1.66173]	[-3.33231]	[2.26359]	[0.00652]	[5.21894]	[-2.17217]	[4.81496]	[-14.2242]
ΔF_{t-2}	---	---	---	---	---	---	---	---
c	0.000618	0.000499	0.000639	0.000658	-0.000289	-0.000280	-4.78E-05	-4.01E-05
	(0.00198)	(0.00196)	(0.00214)	(0.00203)	(0.00214)	(0.00204)	(0.00028)	(0.00032)
	[0.31199]	[0.25449]	[0.29883]	[0.32472]	[-0.13543]	[-0.13713]	[-0.16821]	[-0.12717]
Inference	S→F (LR) F→S (SR)		F↔S (LR) F→S (SR)		F→S (LR) F↔S (SR)		F↔S (LR) F↔S (SR)	
	COPPER		**IRON ORE**		**LEAD**		**NICKEL**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	-0.237239*	0.041819***	0.039809	0.214783*	-0.268082*	0.150307*	-0.172307*	0.073571*
	(0.01521)	(0.02263)	(0.03285)	(0.02870)	(0.02609)	(0.02464)	(0.02372)	(0.02335)
	[-15.5970]	[1.84815]	[1.21182]	[7.48283]	[-10.2735]	[6.09990]	[-7.26382]	[3.15014]
ΔS_{t-1}	-0.106235*	0.017942	0.167933*	0.178193*	-0.179697*	-0.045177***	-0.318463*	-0.029546
	(0.01270)	(0.01889)	(0.05761)	(0.05034)	(0.02603)	(0.02458)	(0.03013)	(0.02966)
	[-8.36702]	[0.94994]	[2.91476]	[3.53973]	[-6.90413]	[-1.83812]	[-10.5706]	[-0.99611]

ΔS_{t-2}	---	---	0.078067 (0.05736) [1.36097]	0.008532 (0.05012) [0.17023]	---	---	-0.170177* (0.02627) [-6.47796]	-0.032750 (0.02586) [-1.26621]
ΔF_{t-1}	0.720796* (0.01934) [37.2648]	0.029339 (0.02877) [1.01962]	0.084530 (0.05586) [1.51322]	0.045540 (0.04881) [0.93303]	0.452265* (0.03104) [14.5702]	0.175217* (0.02931) [5.97777]	0.492065* (0.03233) [15.2200]	0.105450* (0.03183) [3.31285]
ΔF_{t-2}	---	---	-0.014262 (0.05247) [-0.27181]	0.041268 (0.04584) [0.90018]	---	---	0.242394* (0.03113) [7.78753]	0.015813 (0.03064) [0.51601]
c	5.67E-05 (0.00022) [0.25681]	9.47E-05 (0.00033) [0.28829]	1.30E-05 (0.00062) [0.02091]	-0.000321 (0.00054) [-0.59169]	0.000124 (0.00042) [0.29936]	0.000135 (0.00039) [0.34494]	-0.000184 (0.00039) [-0.47549]	-0.000304 (0.00038) [-0.79573]
Inference	F↔S (LR) F→S (SR)		S→F (LR) S→F (SR)		F↔S (LR) F↔S (SR)		F↔S (LR) F↔S (SR)	
	SPONGE IRON		**STEEL FLAT**		**THERMAL COAL**		**TIN**	
	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t	ΔS_t	ΔF_t
ECT	0.001526 (0.00970) [0.15729]	0.050493* (0.01009) [5.00545]	0.031678* (0.01136) [2.78772]	0.093990* (0.01360) [6.91143]	-0.570173* (0.10604) [-5.37672]	0.003528 (0.09615) [0.03670]	-0.025960 (0.02272) [-1.14234]	0.224894* (0.01402) [16.0394]
ΔS_{t-1}	0.110889* (0.04203) [2.63835]	0.070125** (0.04370) [1.67457]	0.004736 (0.04377) [0.10819]	0.097273*** (0.05238) [1.85697]	-0.117164 (0.09183) [-1.27590]	0.028205 (0.08326) [0.33877]	-0.015371 (0.03192) [-0.48151]	0.004125** (0.01970) [1.70945]
ΔS_{t-2}	---	---	---	---	---	---	---	---
ΔF_{t-1}	0.040561 (0.03873) [1.04734]	0.065511** (0.04027) [1.67682]	0.080036* (0.03336) [2.39899]	0.060578 (0.03993) [1.51725]	-0.105533*** (0.09874) [-1.66883]	-0.276493* (0.08952) [-3.08863]	0.005360 (0.04179) [0.12827]	-0.007378 (0.02578) [-0.28615]
ΔF_{t-2}	---	---	---	---	---	---	---	---
c	2.08E-05 (0.00068) [0.03077]	6.65E-05 (0.00070) [0.09463]	9.79E-05 (0.00033) [0.29895]	0.000110 (0.00039) [0.28067]	0.000551 (0.00155) [0.35590]	0.000620 (0.00140) [0.44231]	0.000501 (0.00057) [0.87699]	0.000475 (0.00035) [1.34704]

Inference	S→F (LR) S→F (SR)	F↔S (LR) F↔S (SR)	F→S (LR) F→S (SR)	S→F (LR) S→F (SR)

	ZINC	
	ΔS_t	ΔF_t
ECT	-0.172563* (0.02322) [-7.43049]	0.107783* (0.02462) [4.37846]
ΔS_{t-1}	-0.300951* (0.02862) [-10.5145]	0.028386 (0.03034) [0.93562]
ΔS_{t-2}	-0.202237* (0.02394) [-8.44705]	-0.108632* (0.02538) [-4.28059]
ΔF_{t-1}	0.442519* (0.02976) [14.8678]	-0.056315*** (0.03155) [-1.78502]
ΔF_{t-2}	0.306490* (0.02712) [11.3029]	0.182429* (0.02874) [6.34696]
c	-3.84E-05 (0.00033) [-0.11799]	-0.000148 (0.00035) [-0.42851]
Inference	F↔S (LR) F↔S (SR)	

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SC), F_t and S_t are the Futures and Spot market prices respectively, *, ** and *** denote the significance at the one, five and ten per cent level, respectively. [ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

By and large, the VECM show diverse facts in Table- 6.4. The results from the study of agricultural commodities evidence the presence of extended period unidirectional causation effect which occurs in future market and affects the corresponding spot market prices. This is clearly observed in the case of agricultural commodities namely CRUDE PALM OIL, CORRIANDER, JEERA, POTATO, PEPPER, CHILLI, GAUR, SOYA BEAN, WHEAT, SOYA OIL, MUSTARD OIL and MENTA OIL.

This effect is tested by a feedback long term linkage that occurs between future market price and spot price as is mapped in the case of COTTON SEED OIL CAKE, CHANNA, BARLEY, MAIZE, TURMERIC, SUGAR, GAUR SEED, GAUR GUM and COTTON. There is a one way underlying relationship from spot market prices to future prices and the extended run for KAPAS, RUBBER, PEAS and CASTOR SEEDS.

In addition, a causal one way association exists between future market prices and spot prices in short run for agricultural commodities like CHANNA, CHILLI, KAPAS, MENTA OIL, WHEAT, SOYA OIL, MUSTARD OIL, PEPPER, CASTOR SEEDS, JEERA, BARLEY, COTTON, and MAIZE. (thirteen commodities) This signifies to the fact that market information first gets revealed in through futures prices and then transmission takes place to spot prices of these thirteen commodities.

The tabulated data gives results that confirm presence of short run feedback connection linking future prices and spot markets prices for COTTON SEED OIL CAKE, CORRIANDER, GAUR SEED, GAUR GUM, SUGAR, TURMERIC, PEAS and CRUDE PALM OIL. This confirms the fact that the future prices as well as the spot market prices of the agricultural commodities play an apex role in the price discovery process, provide information promptly and are pro-reactive mutually.

In addition the tabulated data reveals unidirectional causal association connecting spot market price to future prices, as mapped in the case of SOYA BEAN, RUBBER and POTATO. This confirms that in the case of the three commodities the spot market prices play a dominant role and perform a very proficient price discovery function.

As regards the scrutiny of VECM, Bullion shows that long-run bidirectional relation between futures and spot markets in the case of GOLD and SILVER. And futures price leads to spot price for PLATINUM in the long-run. For short-run, futures lead spot and spot lead futures price in the case of GOLD and PLATINUM, respectively. For SILVER, bidirectional causation between futures and spot market prices exists in the short-run.

As far as the Energy commodities are concerned, the VECM in table- 6.4 reports that the long-run bidirectional causation linking spot and futures market prices as in the given case with regard to CRUDE OIL and HEATING OIL and unilateral causality from the future market price leading to the spot price with regard to ATF, BRENT CRUDE OIL, NATURAL GAS and FURNACE OIL.

Further, the results show the short-run causality from the future market price leading to the spot price with regard to ATF, BRENT CRUDE OIL, GASOLINE, HEATING OIL and FURNACE OIL and bilateral causation between futures and spot market prices for NATURAL GAS. And short-run causality runs from spot to futures market price for CRUDE OIL.

In the case of Metal stocks, the VECM table result depicts the long-run bidirectional causation between futures and spot market prices for the ALUMINIUM, COPPER, LEAD, NICKEL, STEEL FLAT and ZINC, long-run unilateral causation from futures to spot price and reverse in case of THERMAL COAL and IRON ORE, SPONGE IRON and TIN, respectively.

Besides the VECM table result shows the short-run bidirectional relationship between spot and futures markets in the case of five Metal stocks, viz. ALUMINIUM, NICKEL, LEAD, STEEL FLAT and ZINC. This shows that both the spot and future markets is efficient with regard to the information and is able to react immediately with each other. The analysis also confirms that spot leads to futures price and futures leads to spot market price in the case of IRON ORE, SPONGE IRON and TIN and COPPER and THERMAL COAL, respectively.

On the whole, from the study results, it is clear that the unilateral causation runs from futures market price to spot market price in majority of the underlying commodities that belong to Agriculture and Energy sector. And Bullions show mixed evidence. Following this, the feedback relationship exists between spot and futures market prices in majority of the underlying commodities that belongs to Metals. The variation of price discovery mechanism from one commodity to another is due to the fact that the selected underlying commodities from different industry groups are widely dispersed in terms of its industry-specific activities and also they are subject towards prevailing differential market frictions such as transaction costs, initial margin requirements, leverage positions and flexibility of short positions and liquidity differences between spot and futures markets. Besides, the present study suggests that depending on the relative proportion of informed to uninformed (noise) traders migrating from the spot market to the futures market, the lead-lag relationship between futures and spot market of selected underlying commodities of respective industry groups may differ.

II. Volatility Spillover

6.6 ARCH LM Test:

Furthermore, the Engle (1982) ARCH-LM test statistics was conducted in order to test the null hypothesis of no ARCH effects and its results are reported in the Table- 6.5. The test

statistics are highly significant at one percent levels, confirming the existence of significant ARCH effects on the futures and spot return data series of all selected underlying commodities of different sectors.

Table- 6.5 ARCH LM Test Results of Individual Commodities Spot and Futures Markets Return

Name of the Commodity	ARCH LM Statistics			
	Spot Returns	Prob. Value	Futures Returns	Prob. Value
AGRICULTURE				
BARLEY	45.324	0.000	53.975	0.000
CASTER SEEDS	630.67	0.000	46.567	0.000
CHANNA	664.65	0.000	119.20	0.000
CHILLI	99.636	0.000	679.99	0.000
CORRIANDER	45.324	0.000	53.975	0.000
COTTON SEED OIL CAKE	630.67	0.000	46.567	0.000
COTTON	664.65	0.000	119.20	0.000
CRUDE PALM OIL	99.636	0.000	679.99	0.000
GAUR GUM	45.324	0.000	53.975	0.000
GAUR SEED	630.67	0.000	46.567	0.000
GAUR	664.65	0.000	119.20	0.000
JEERA	99.636	0.000	679.99	0.000
KAPAS	45.324	0.000	53.975	0.000
MAIZE	630.67	0.000	46.567	0.000
MENTA OIL	664.65	0.000	119.20	0.000
MUSTARD OIL	99.636	0.000	679.99	0.000
PEAS	45.324	0.000	53.975	0.000
PEPPER	630.67	0.000	46.567	0.000
POTATO	664.65	0.000	119.20	0.000
RUBBER	99.636	0.000	679.99	0.000
SOYA BEAN	45.324	0.000	53.975	0.000
SOYA OIL	630.67	0.000	46.567	0.000
SUGAR	664.65	0.000	119.20	0.000
TURMERIC	99.636	0.000	679.99	0.000
WHEAT	45.324	0.000	53.975	0.000
BULLION				
GOLD	630.67	0.000	46.567	0.000
PLATINUM	664.65	0.000	119.20	0.000
SILVER	99.636	0.000	679.99	0.000
ENERGY				
ATF	45.324	0.000	53.975	0.000
BRENT CRUDE OIL	630.67	0.000	46.567	0.000
CRUDE OIL	664.65	0.000	119.20	0.000
FURNACE OIL	99.636	0.000	679.99	0.000
HEATING OIL	45.324	0.000	53.975	0.000
GASOLINE	630.67	0.000	46.567	0.000
NATURAL GAS	664.65	0.000	119.20	0.000

METAL				
ALUMINIUM	99.636	0.000	679.99	0.000
COPPER	45.324	0.000	53.975	0.000
IRON ORE	630.67	0.000	46.567	0.000
LEAD	664.65	0.000	119.20	0.000
NICKEL	99.636	0.000	679.99	0.000
SPONGE IRON	45.324	0.000	53.975	0.000
STEEL FLAT	630.67	0.000	46.567	0.000
THERMAL COAL	664.65	0.000	119.20	0.000
TIN	99.636	0.000	679.99	0.000
ZINC	45.324	0.000	53.975	0.000

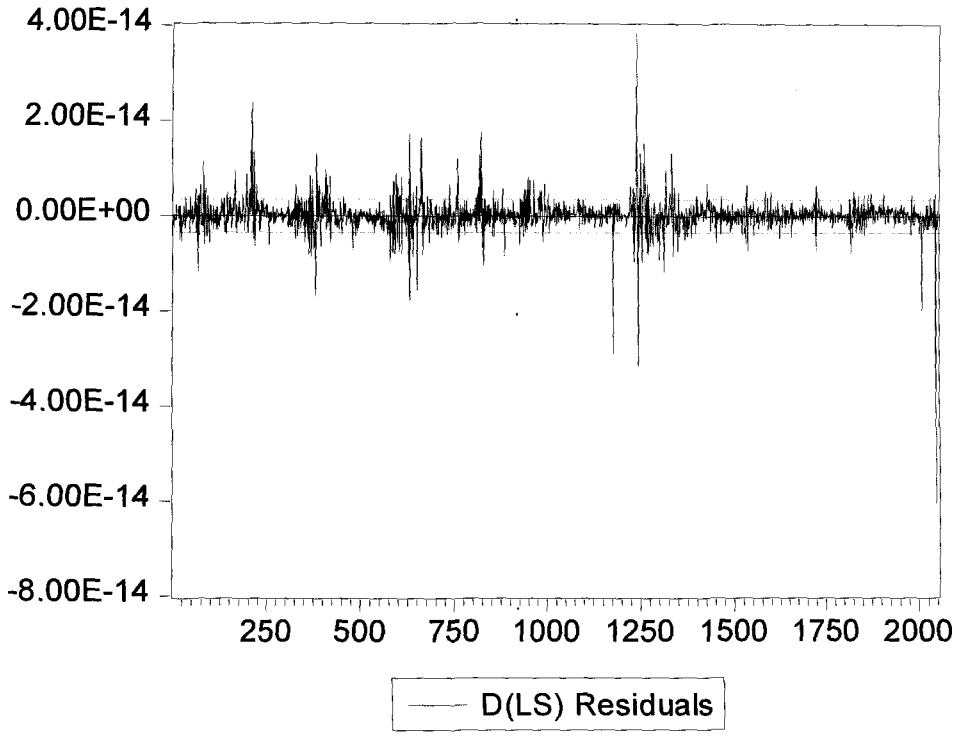
Besides, Figure 6.1 to 6.45 shows the volatility clustering of spot and futures commodity market returns of individual commodities, namely CHANNA, BARLEY, CASTOR SEEDS, CHILLI, CORRIANDER, CRUDE PALM OIL, COTTON SEED OIL CAKE, GAUR, JEERA, COTTON, GAUR GUM, GAUR SEED, KAPAS, MENTA OIL, MAIZE, MUSTARD OIL, PEAS, POTATO, PEPPER, RUBBER, SOYA BEAN, SUGAR, SOYA OIL, TURMERIC, WHEAT, SILVER, GOLD, PLATINUM, ATF, CRUDE OIL, BRENT CRUDE OIL, FURNACE OIL, NATURAL GAS, HEATING OIL, GASOLINE, ALUMINIUM, IRON ORE, COPPER, LEAD, SPONGE IRON, NICKEL, STEEL FLAT, ZINC, TIN and THERMAL COAL respectively. The graphical representation of the residuals obtained from the spot and futures commodity market returns of underlying stocks exhibit significant ARCH effects i.e. volatility clustering or volatility persistence.

By and large, the evidence from the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests result reveals that the hypothesis of a unit root in the futures and spot return series of all selected commodities is strongly rejected. Therefore, returns follow a stationary process even though they fail to be normally distributed because of the presence of ARCH effects. The futures and spot return prices pertaining to all the selected Bullion, Agriculture, Energy and Metal commodities seemed have unconditional leptokurtic distribution giving a good description of the same. The ARCH effects is further proved by the ARCH LM values

as well as Graphical representation, i.e. volatility clustering. The Bivariate EGARCH model adequately maps the heteroscedastic effects and volatility clustering to enable modelling of the volatility of future and spot prices of the selected commodities.

By and large, the evidence from the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests result reveals that the hypothesis of a unit root in the futures and spot return series of all selected commodities is strongly rejected. Therefore, returns follow a stationary process even though they fail to be normally distributed because of the presence of ARCH effects. The spot and futures return series of all selected underlying commodities of Agriculture, Bullion, Energy and Metal appear to be best described by an unconditional leptokurtic distribution and possesses significant ARCH effects which is confirmed by ARCH LM test statistics as well as Graphical representation, i.e. volatility clustering. This suggests that the Bivariate EGARCH model is capable with generalised error distribution (GED) is deemed fit for modelling the spot and futures return volatility of these commodities, as it sufficiently captures the volatility clustering and heteroscedastic effects.

Figure 6.1: Volatility Clustering of Spot and Futures Commodity Market Returns of BARLEY



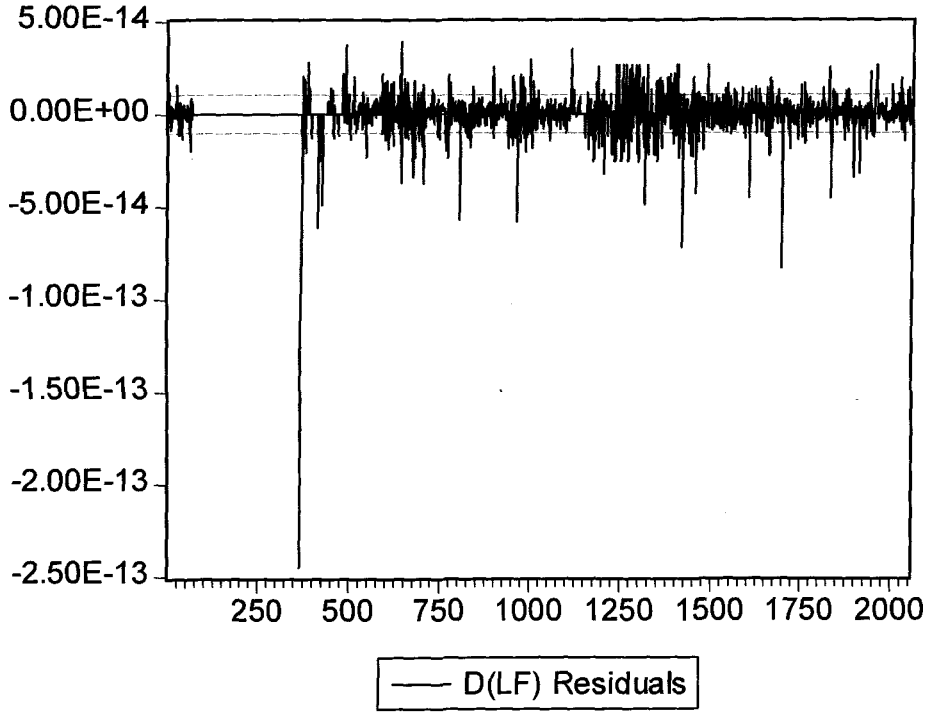
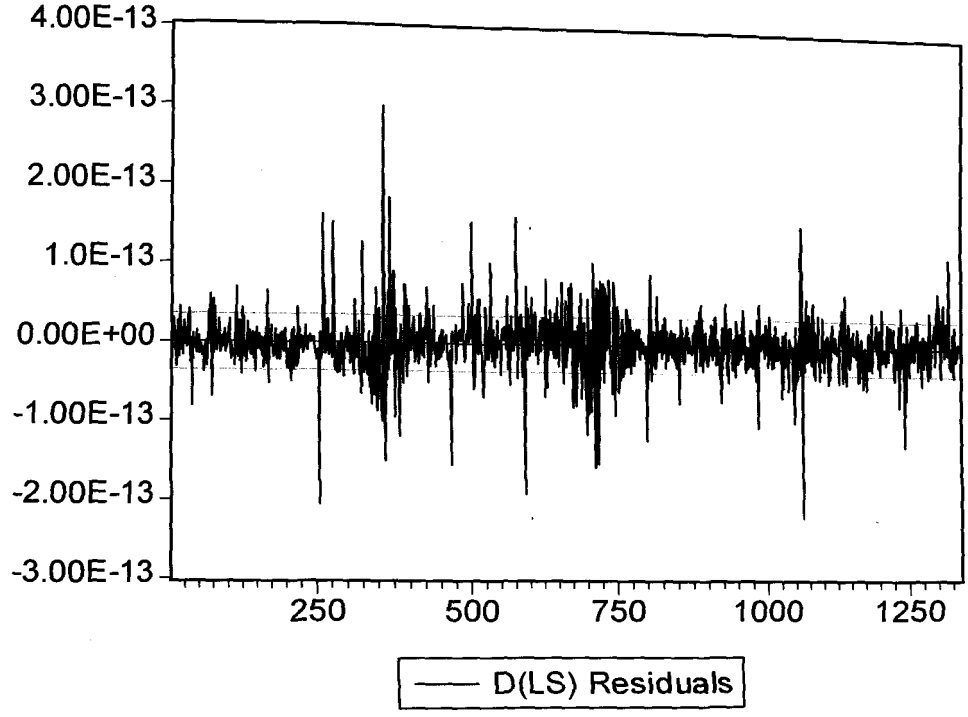


Figure 6.2: Volatility Clustering of Spot and Futures Commodity Market Returns of CASTOR SEEDS



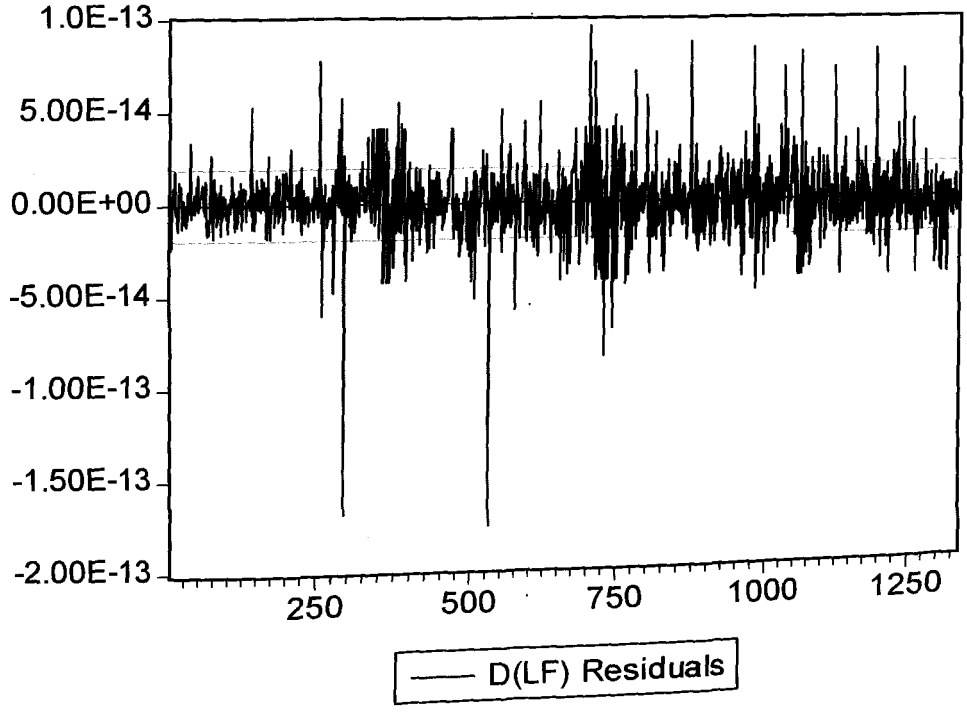
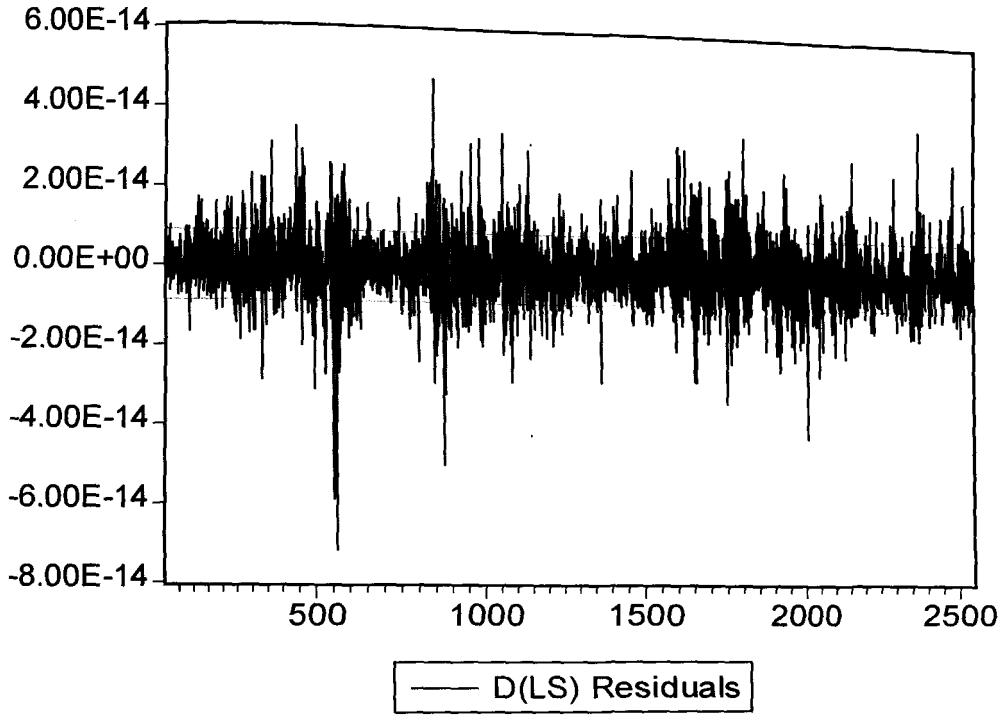


Figure 6.3: Volatility Clustering of Spot and Futures Commodity Market Returns of CHANNA



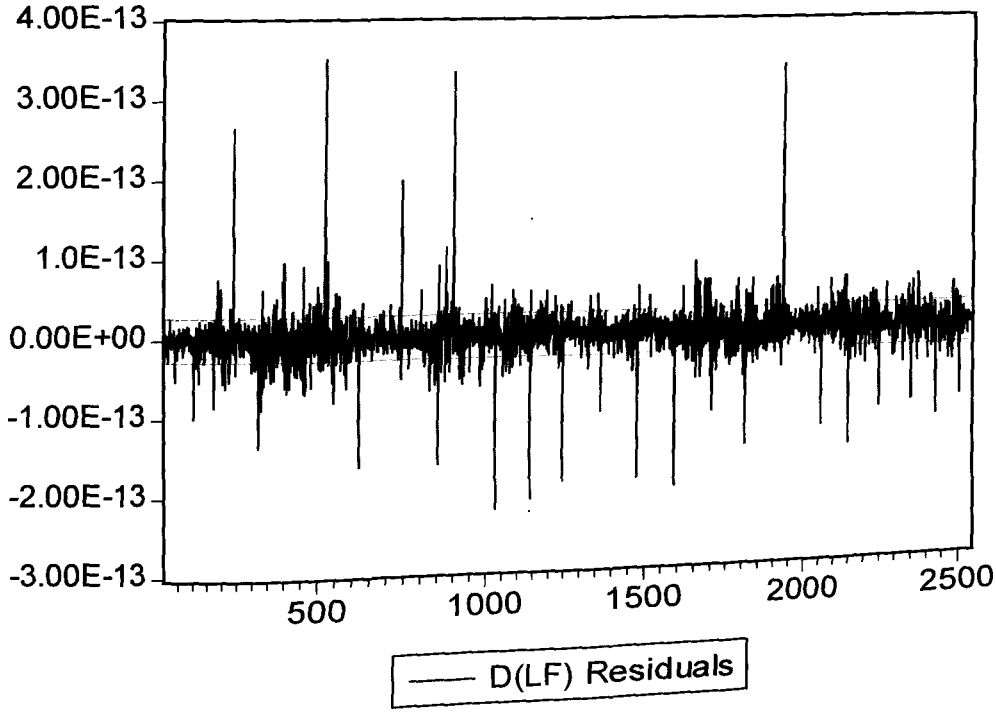
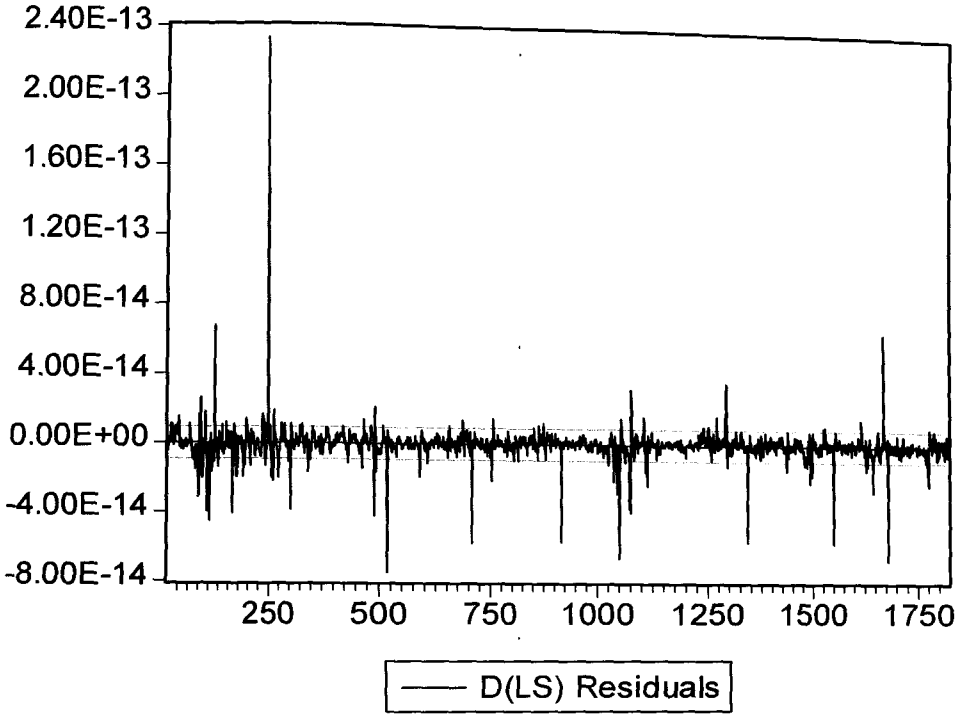


Figure 6.4: Volatility Clustering of Spot and Futures Commodity Market Returns of CHILLI



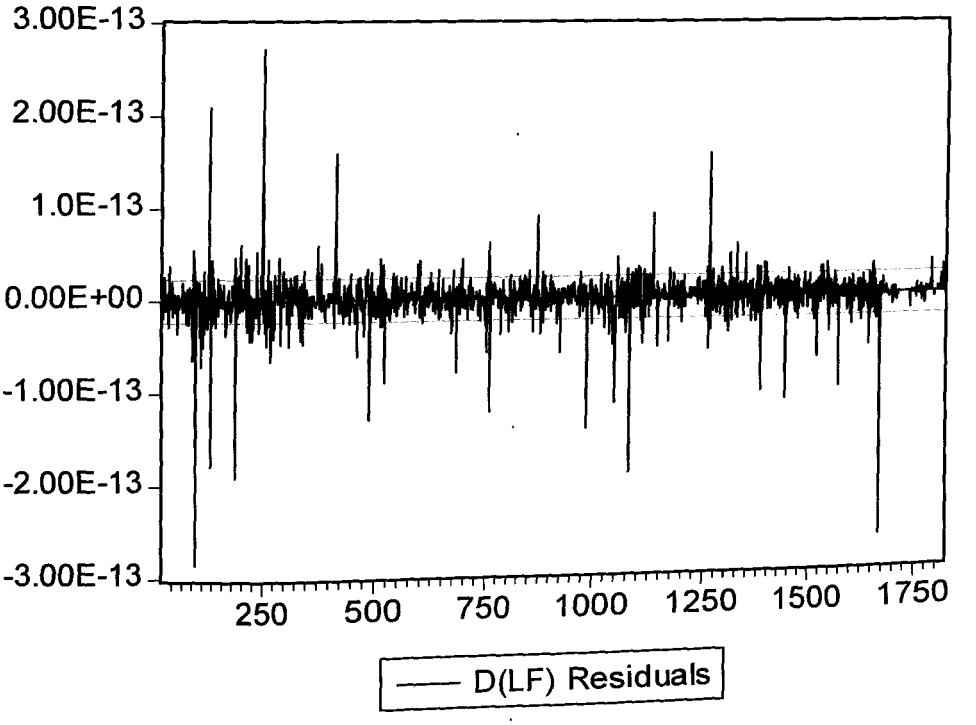
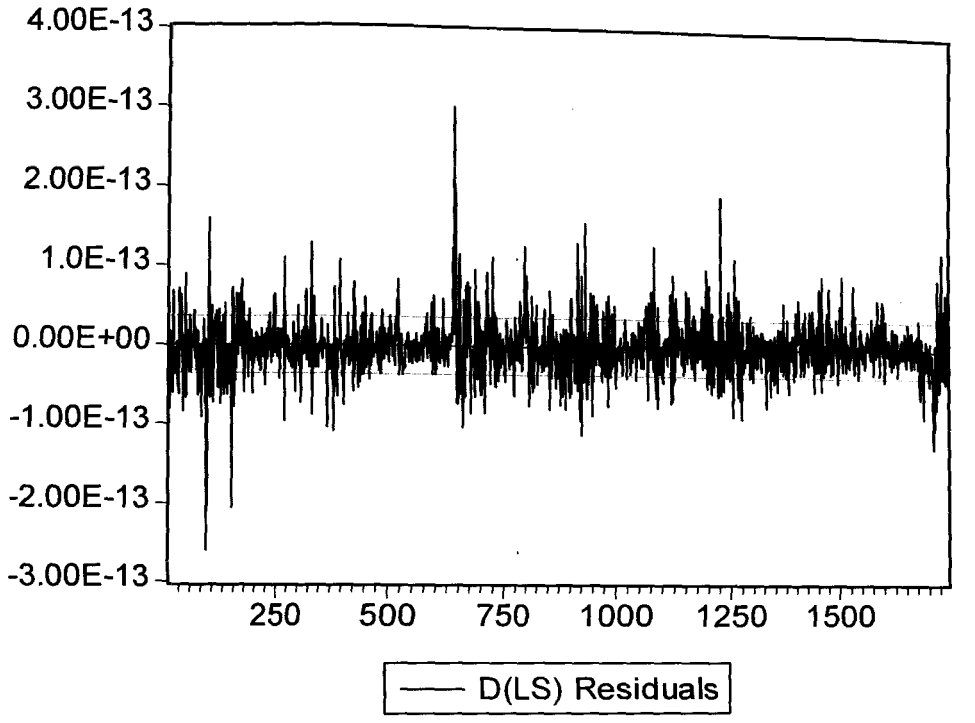


Figure 6.5: Volatility Clustering of Spot and Futures Commodity Market Returns of CORRIANDER



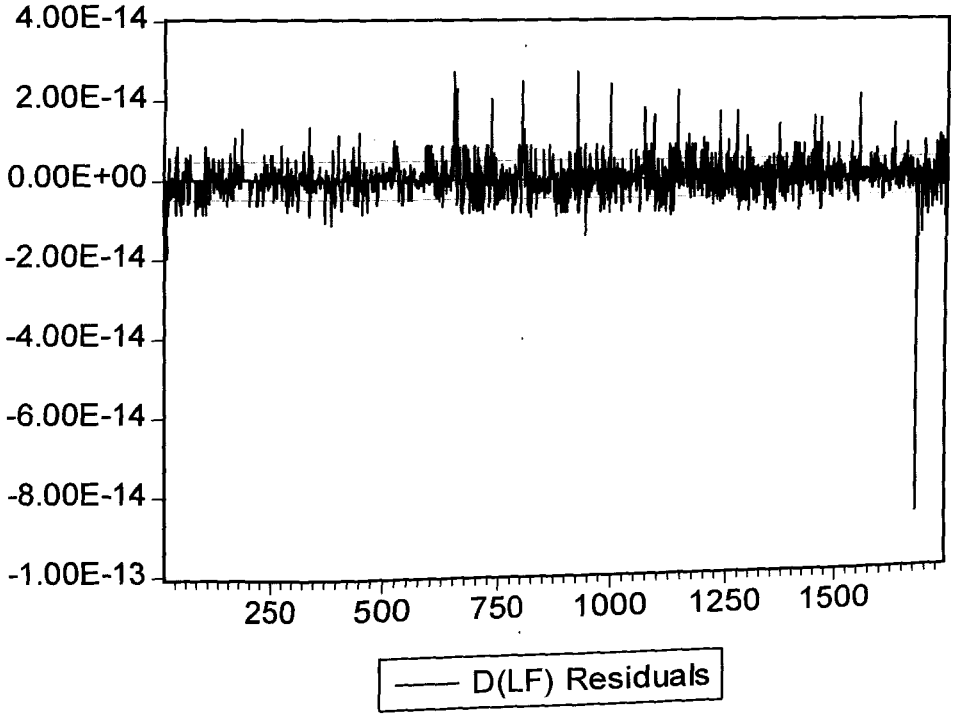
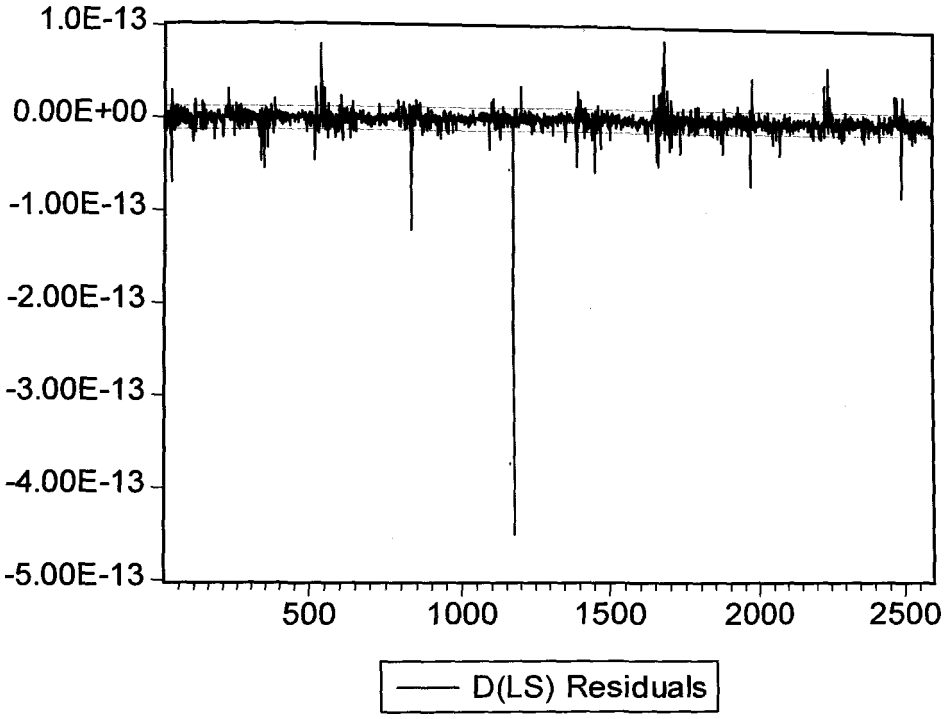


Figure 6.6: Volatility Clustering of Spot and Futures Commodity Market Returns of COTTON SEED OIL CAKE



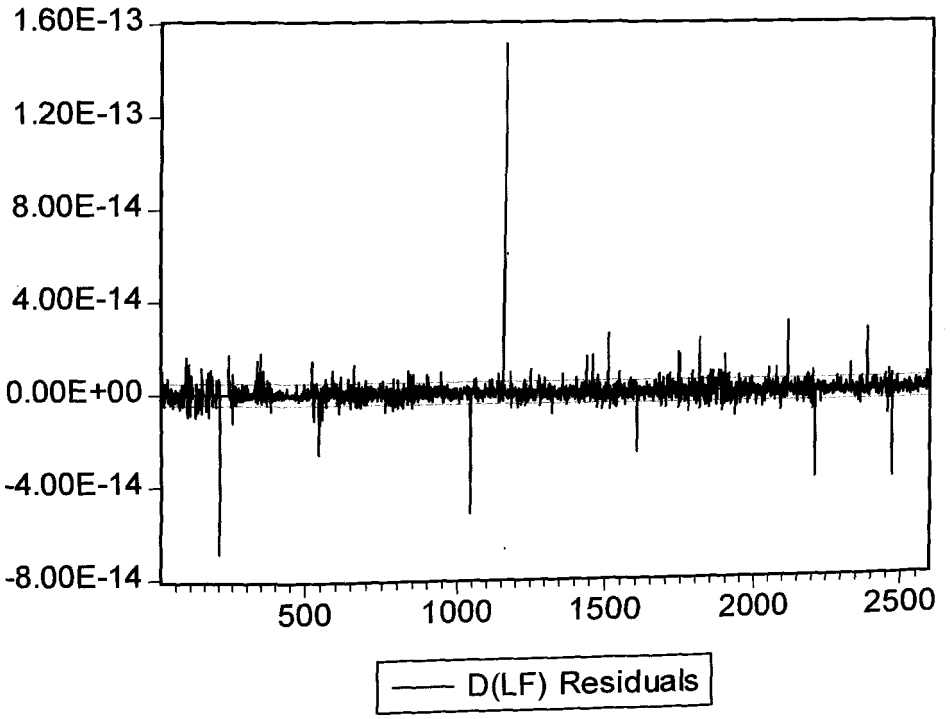
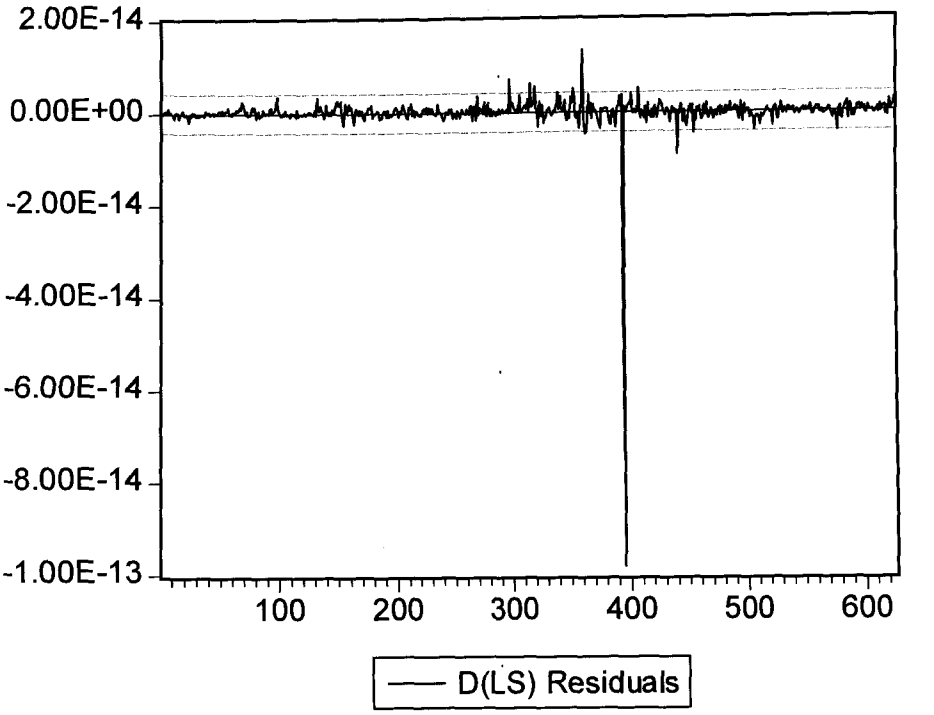


Figure 6.7: Volatility Clustering of Spot and Futures Commodity Market Returns of COTTON



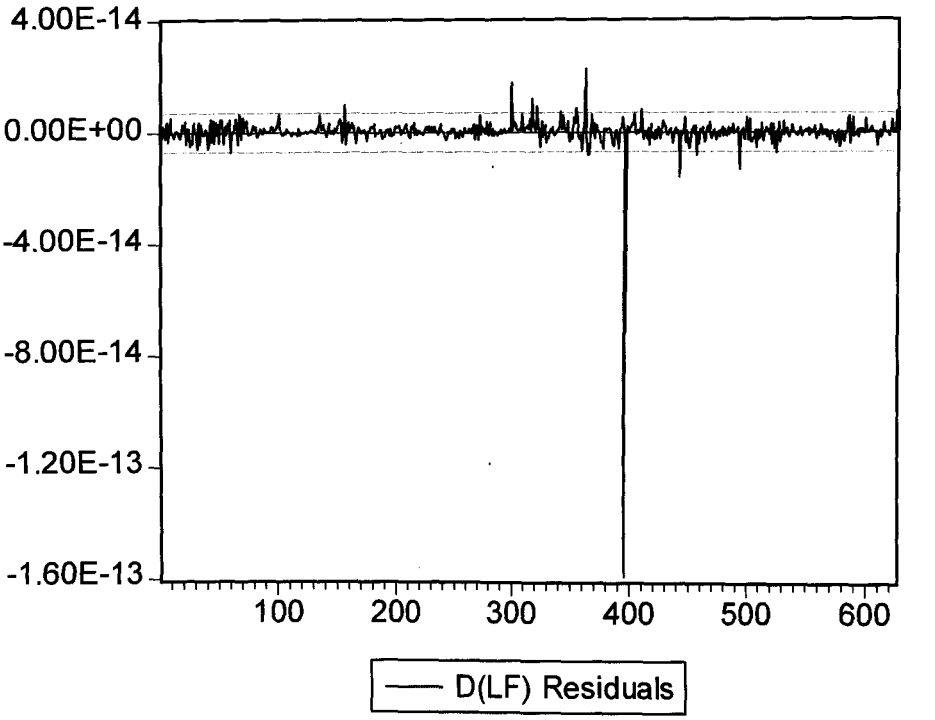
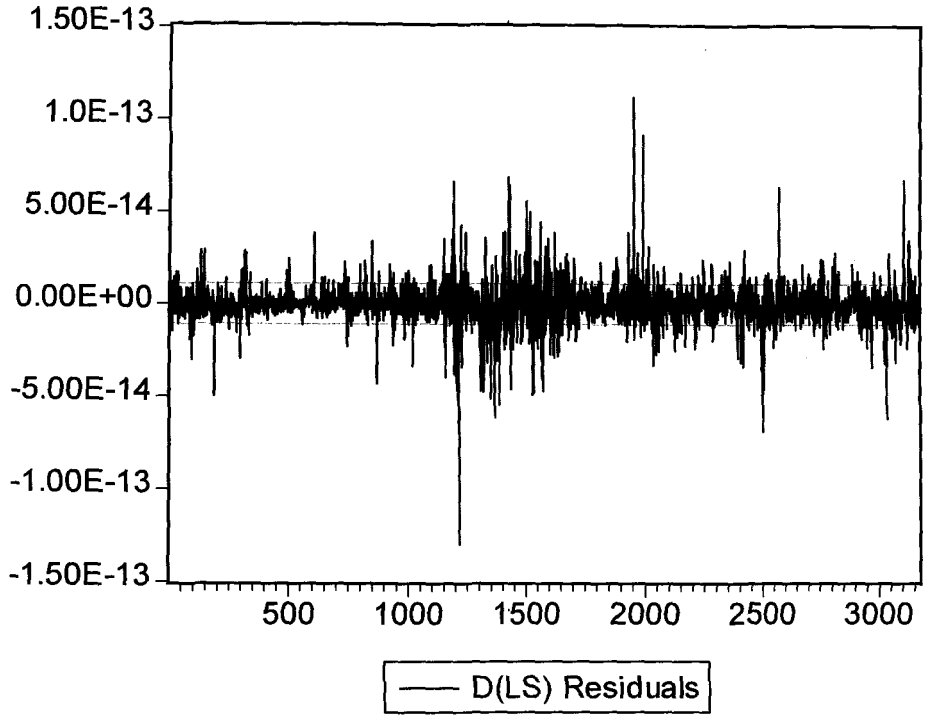


Figure 6.8: Volatility Clustering of Spot and Futures Commodity Market Returns of CRUDE PALM OIL



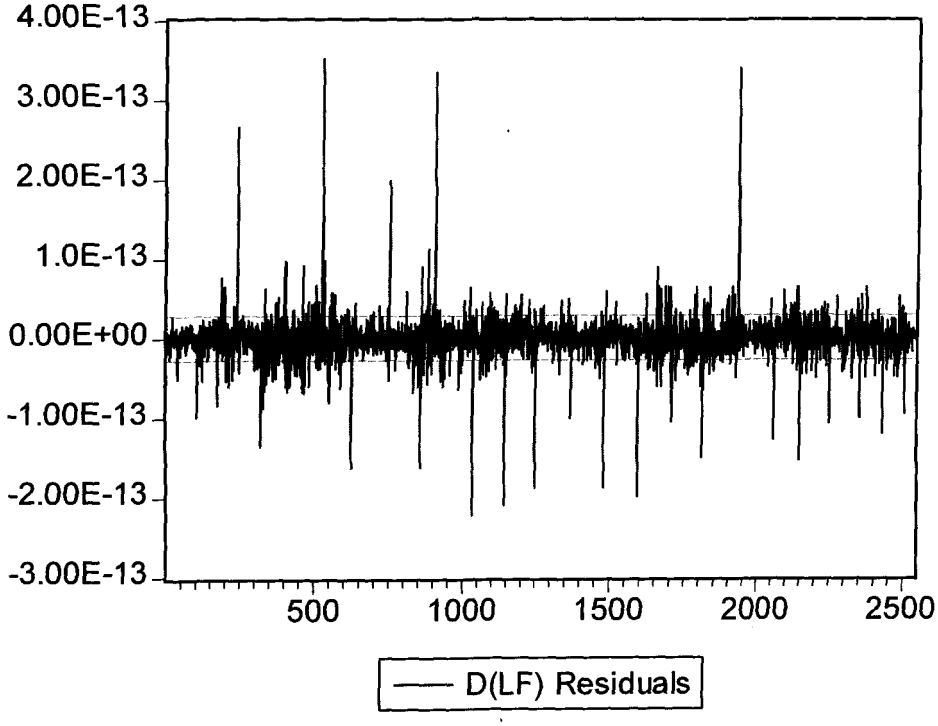
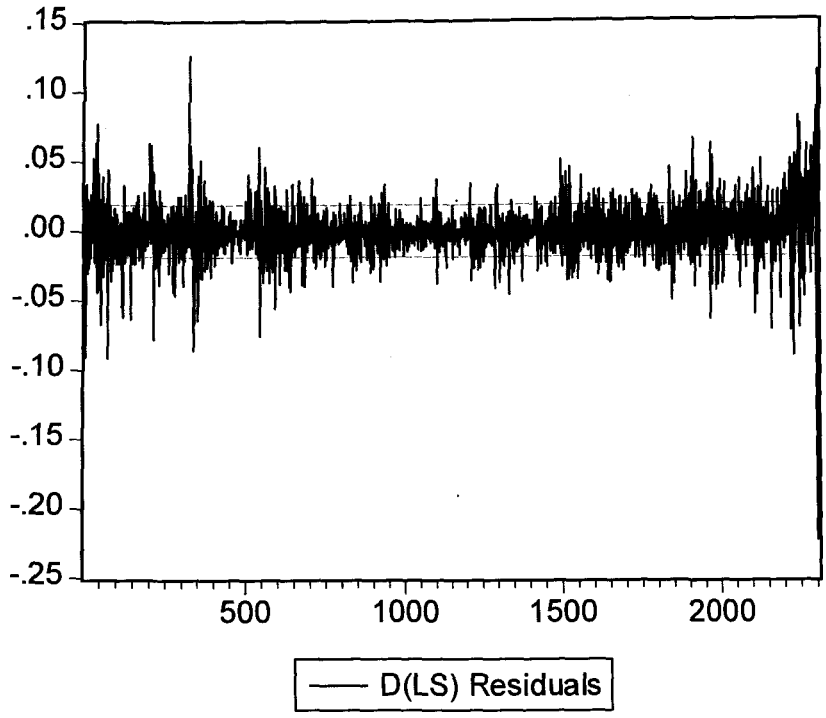


Figure 6.9: Volatility Clustering of Spot and Futures Commodity Market Returns of GAUR GUM



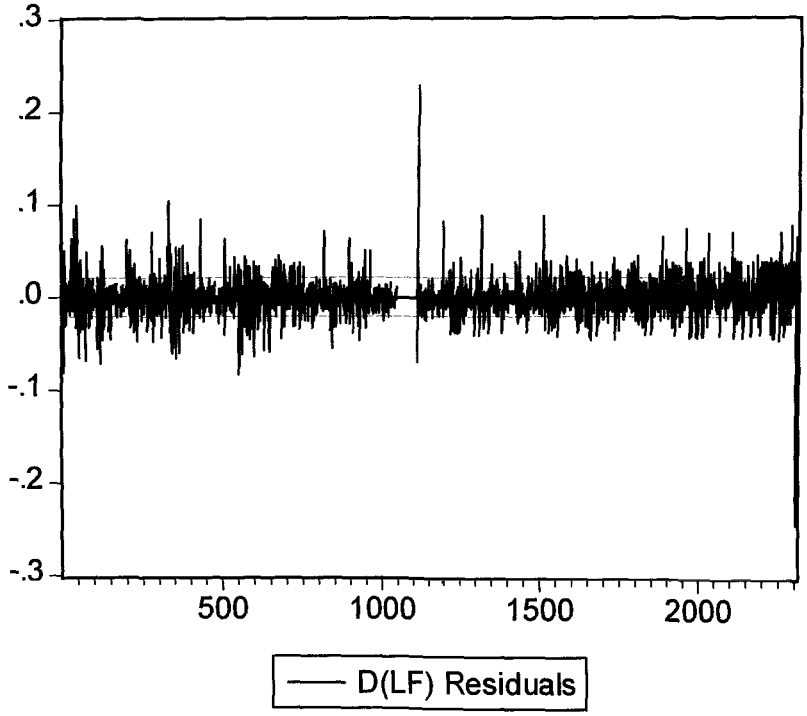
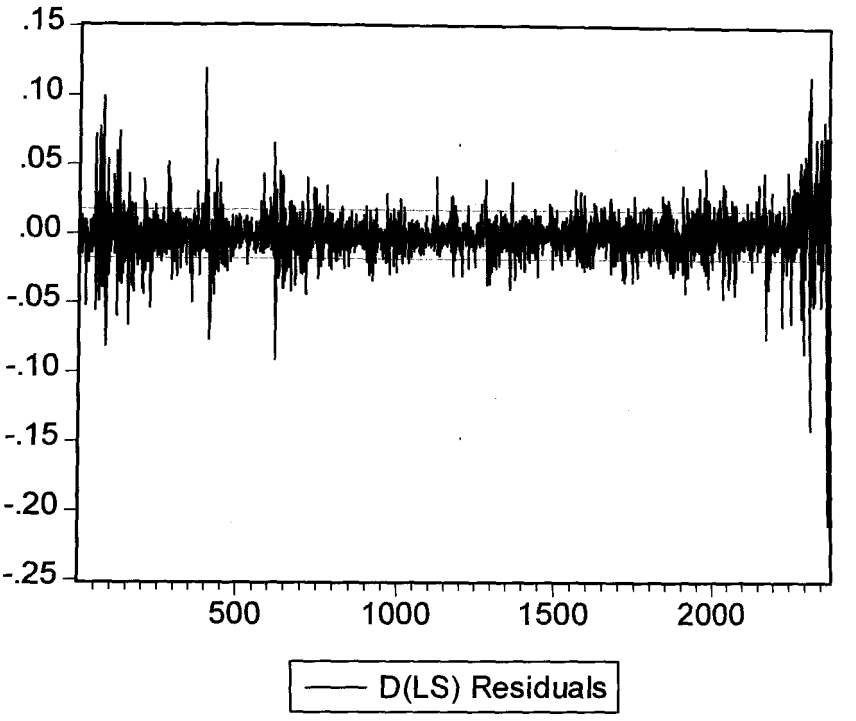


Figure 6.10: Volatility Clustering of Spot and Futures Commodity Market Returns of GAUR SEED



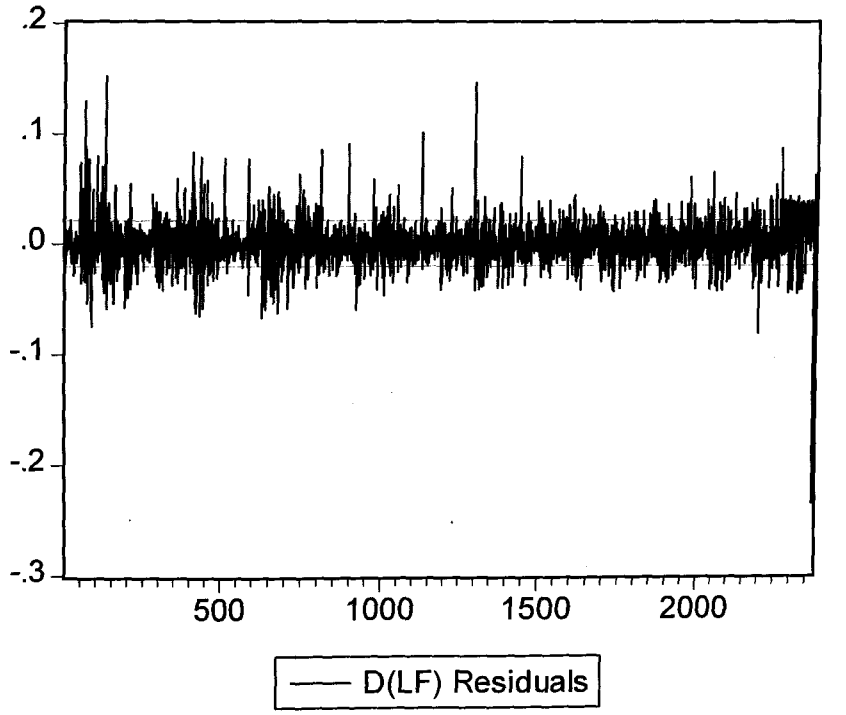


Figure 6.11: Volatility Clustering of Spot and Futures Commodity Market Returns of GAUR

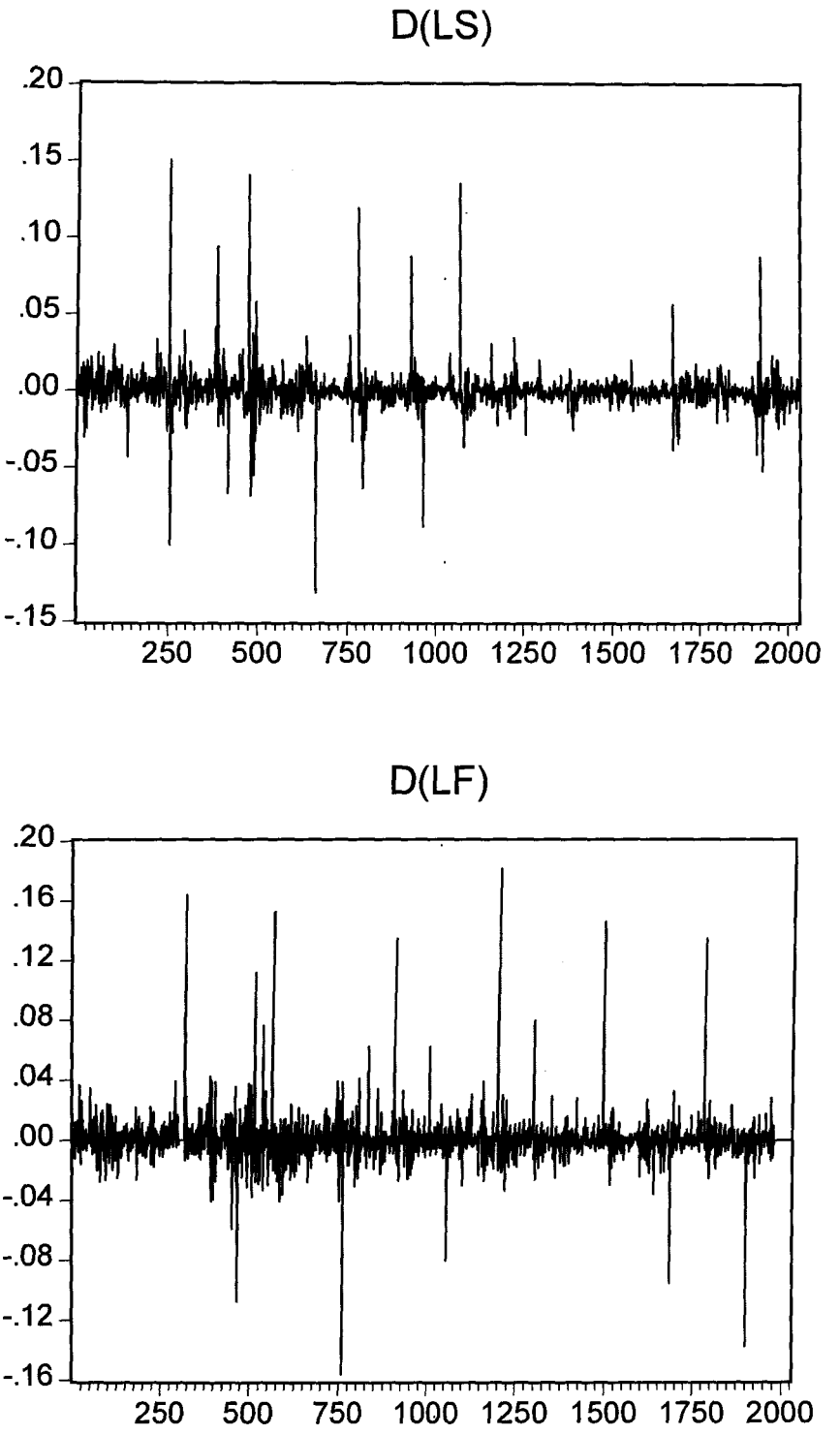


Figure 6.12: Volatility Clustering of Spot and Futures Commodity Market Returns of JEERA

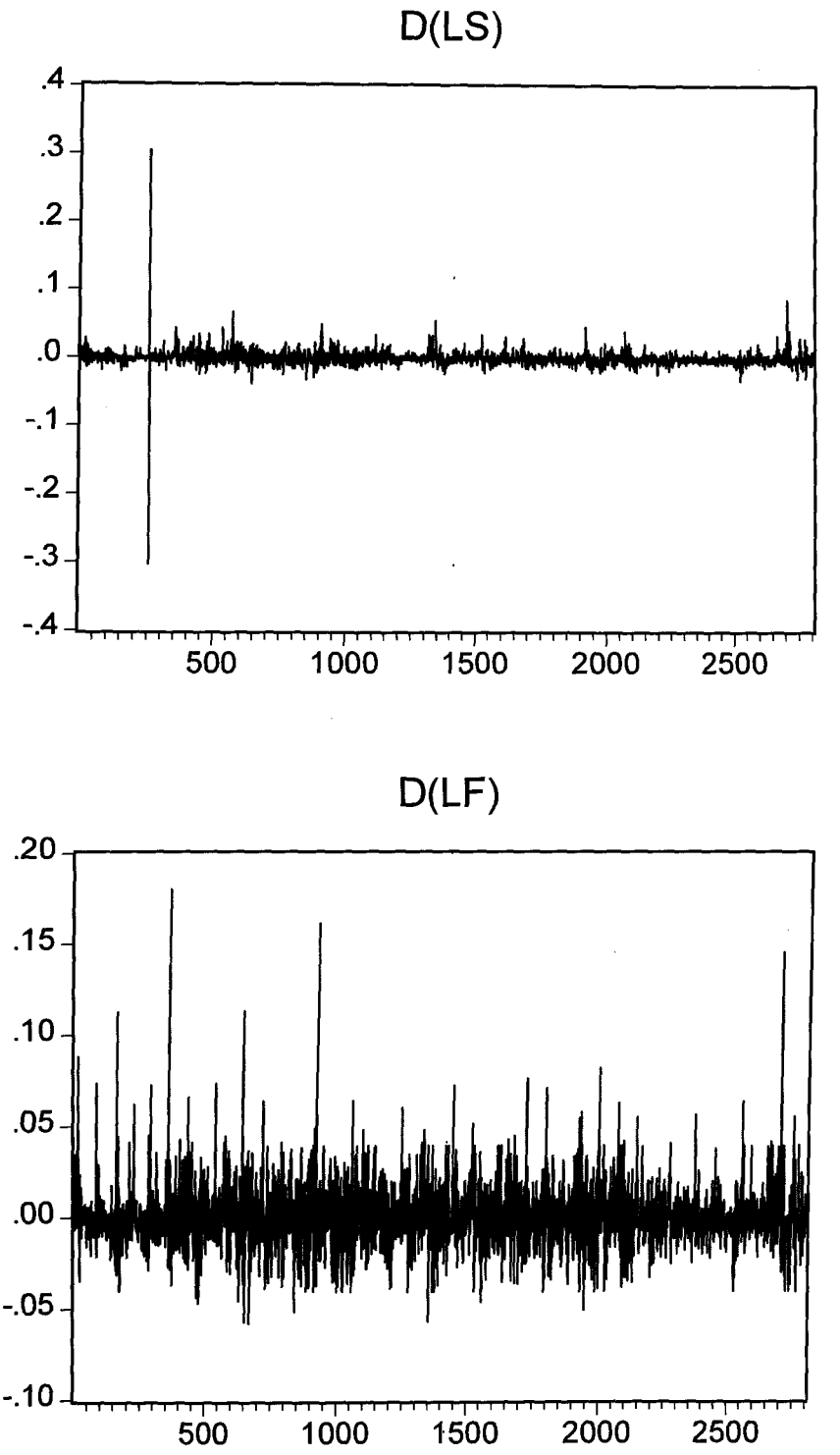


Figure 6.13: Volatility Clustering of Spot and Futures Commodity Market Returns of KAPAS

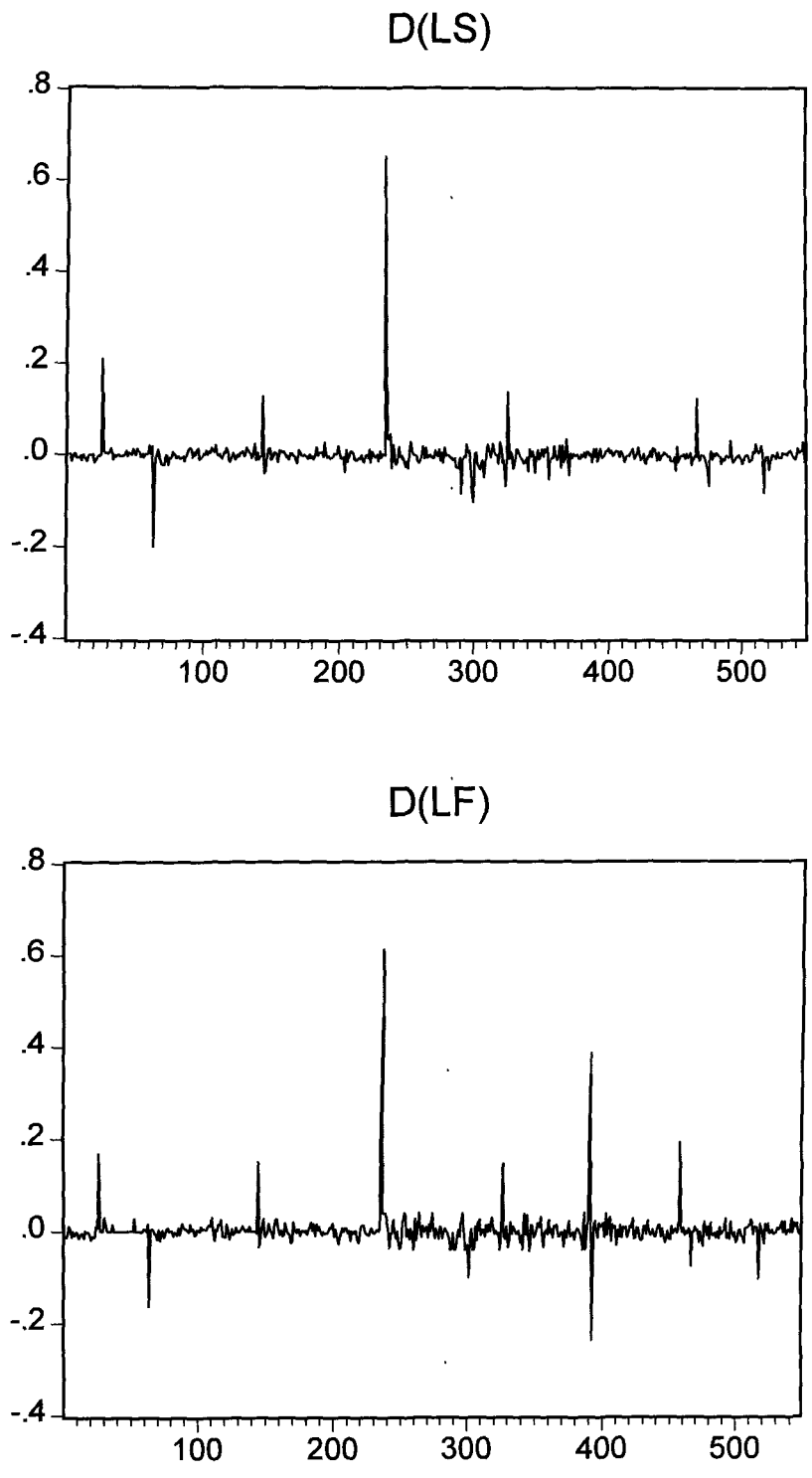


Figure 6.14: Volatility Clustering of Spot and Futures Commodity Market Returns of MAIZE

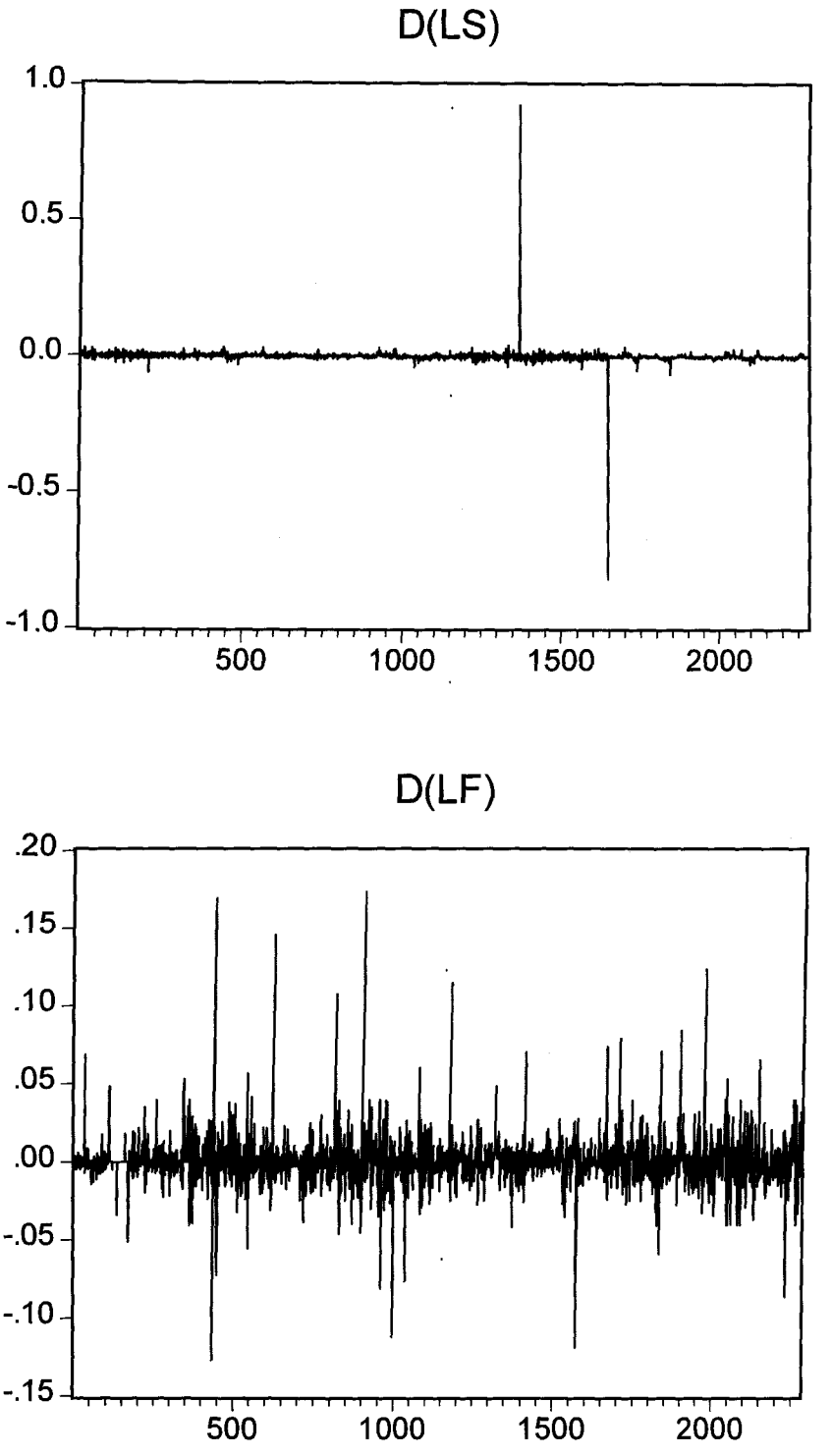


Figure 6.15: Volatility Clustering of Spot and Futures Commodity Market Returns of MENTA OIL

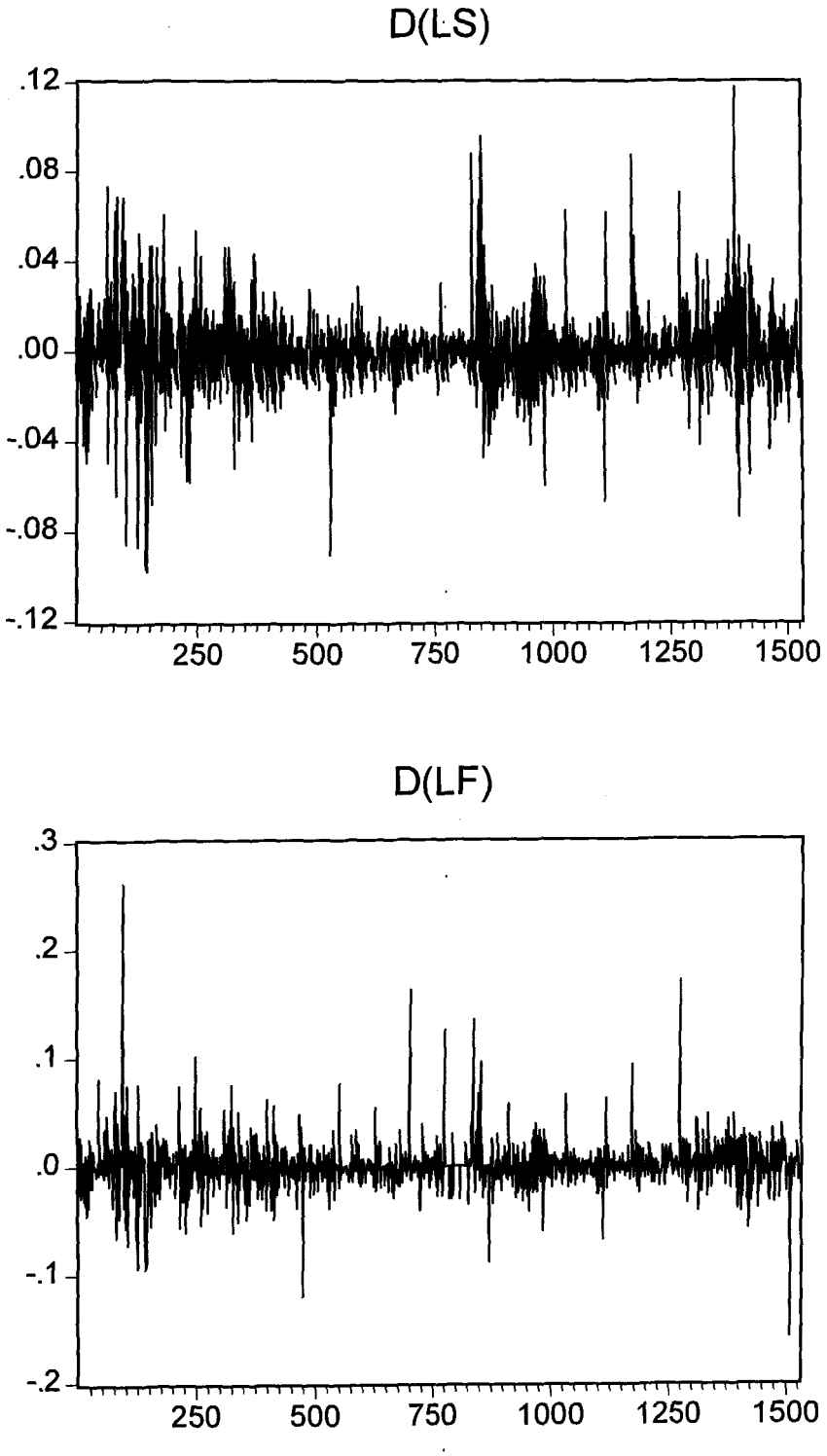


Figure 6.16: Volatility Clustering of Spot and Futures Commodity Market Returns of MUSTARD OIL

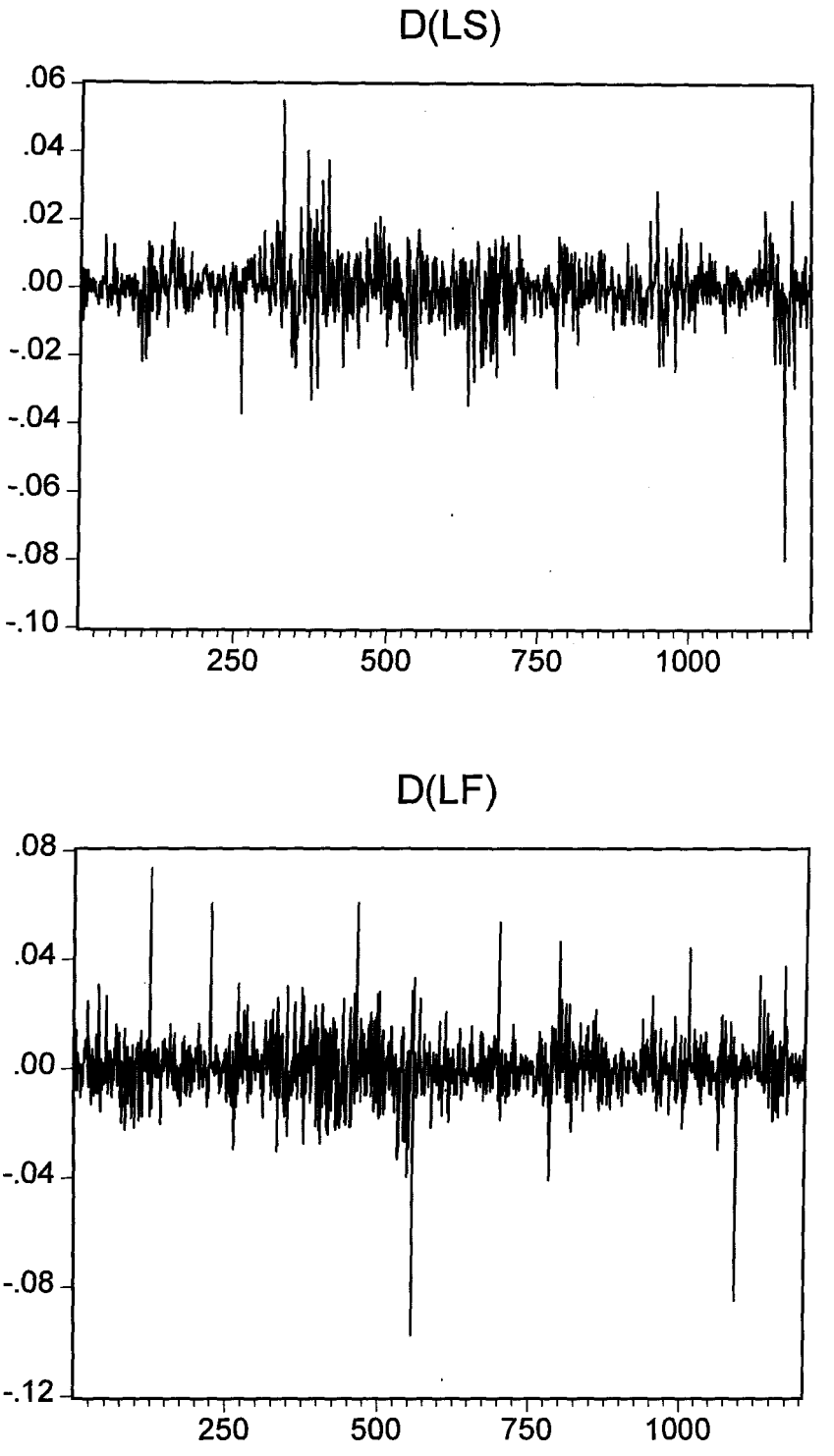


Figure 6.17: Volatility Clustering of Spot and Futures Commodity Market Returns of PEAS

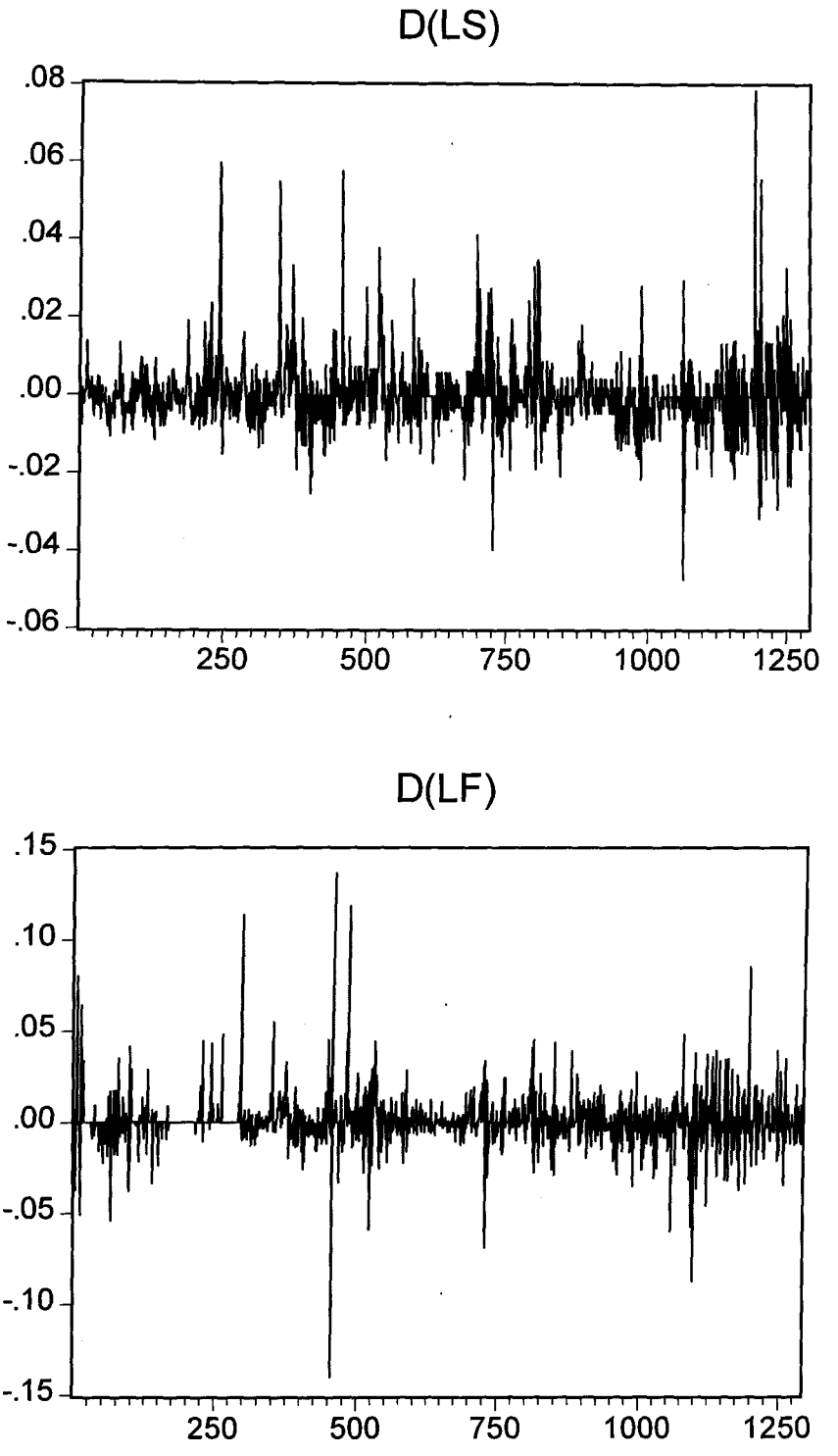
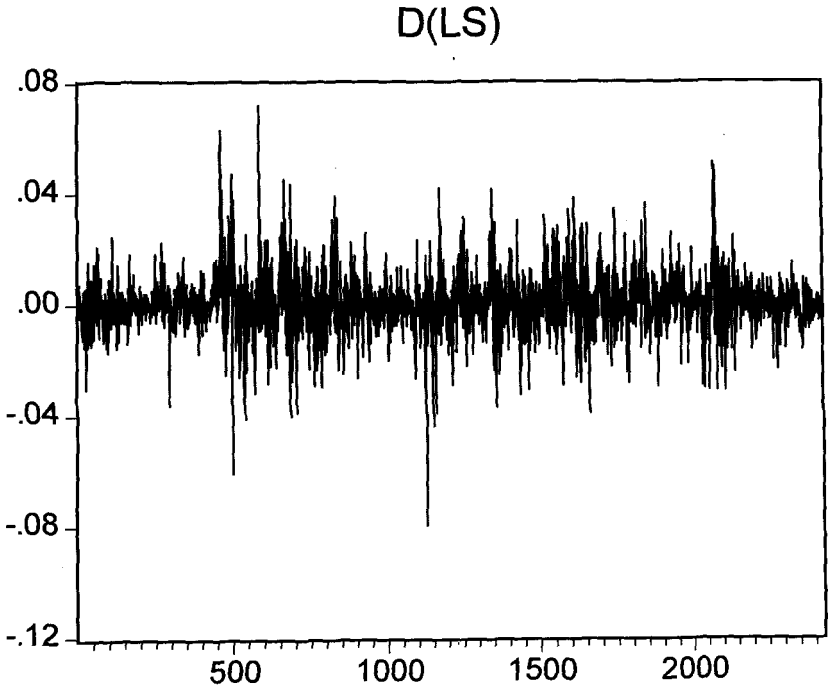


Figure 6.18: Volatility Clustering of Spot and Futures Commodity Market Returns of PEPPER



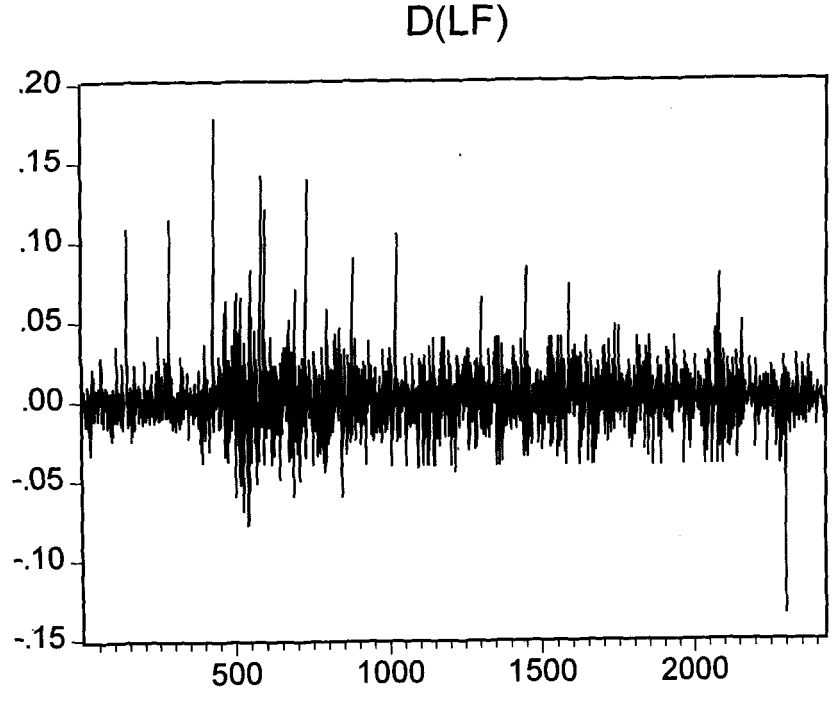


Figure 6.19: Volatility Clustering of Spot and Futures Commodity Market Returns of POTATO

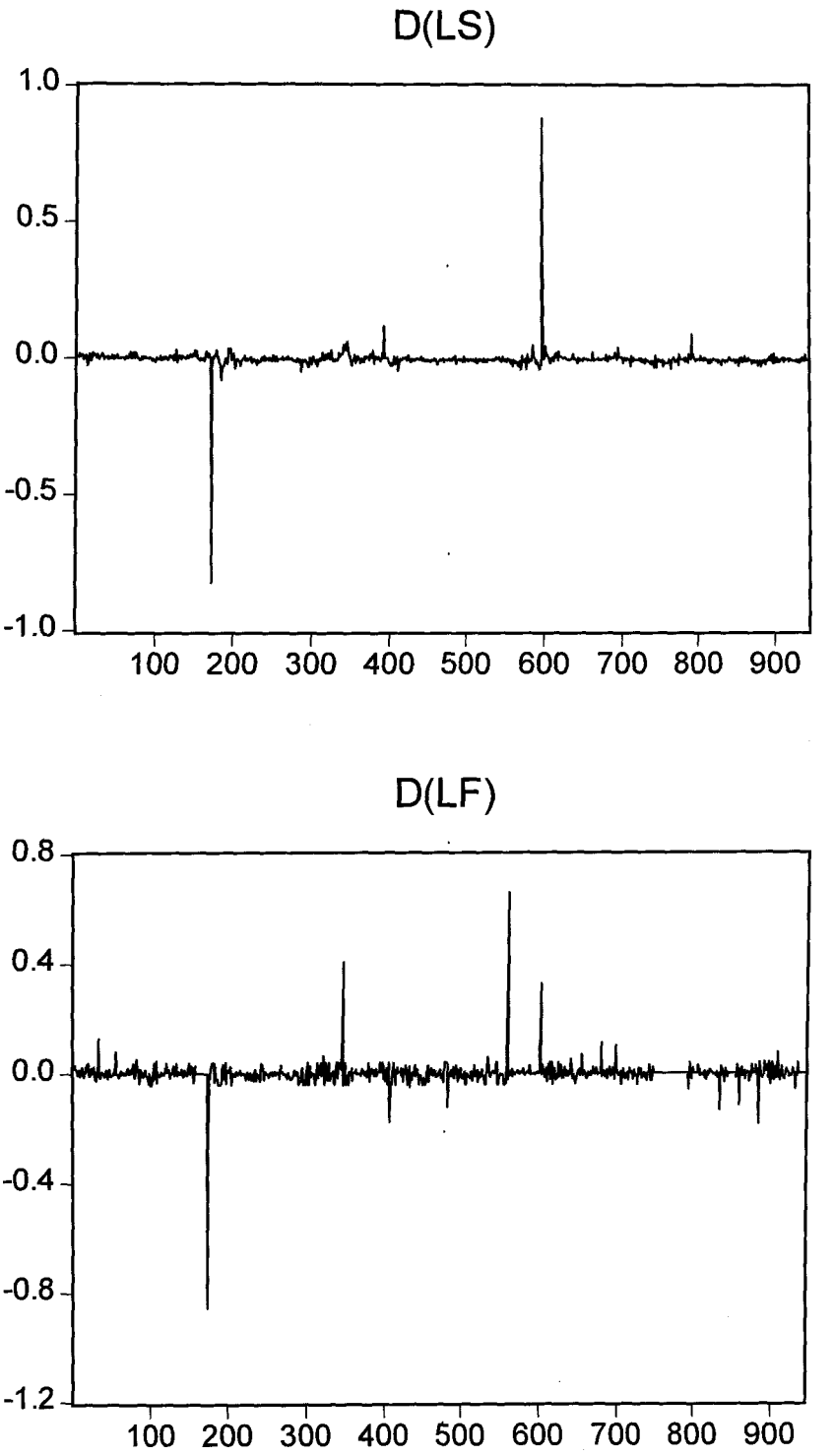


Figure 6.20: Volatility Clustering of Spot and Futures Commodity Market Returns of RUBBER

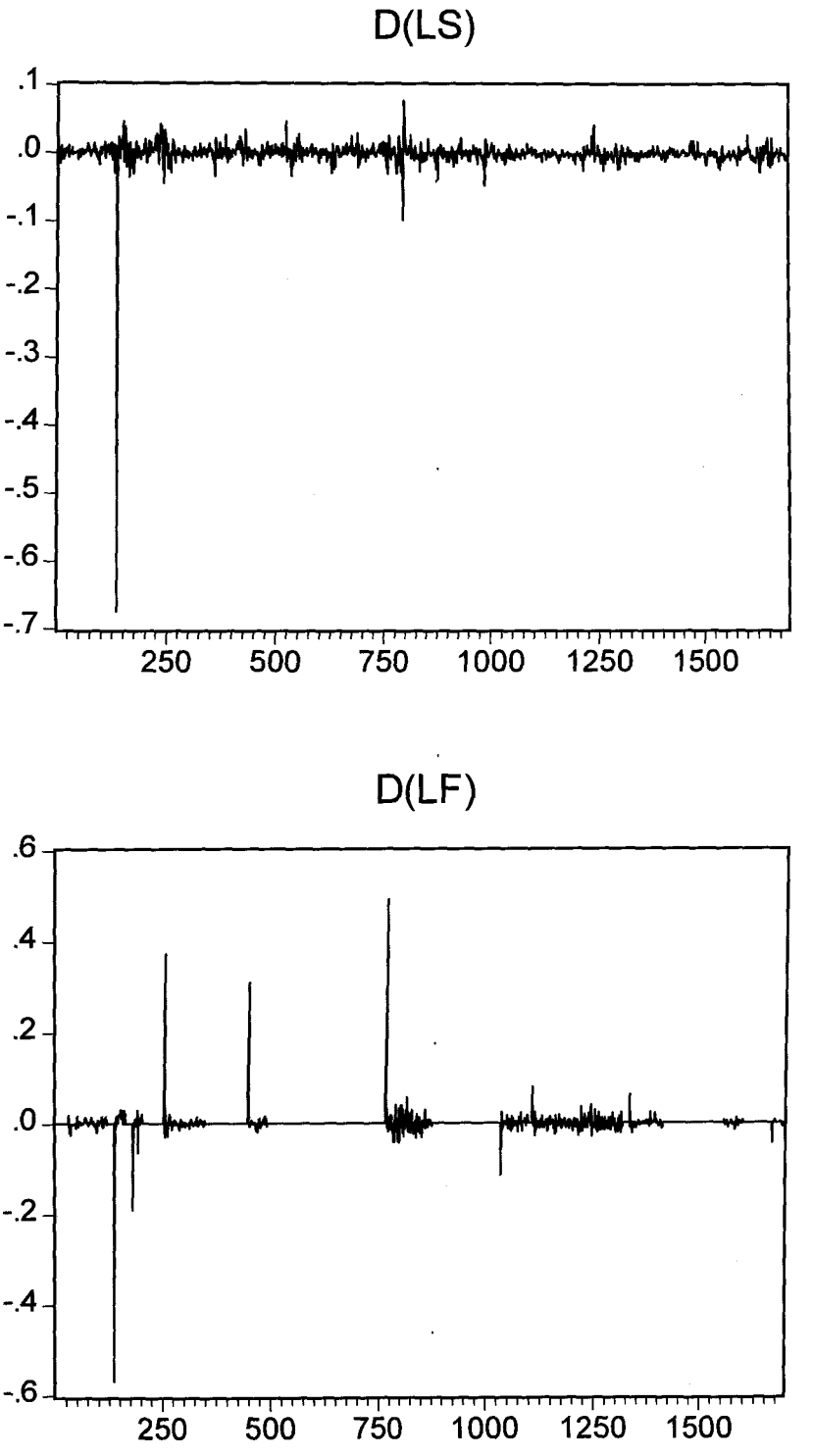


Figure 6.21: Volatility Clustering of Spot and Futures Commodity Market Returns of SOYA BEAN

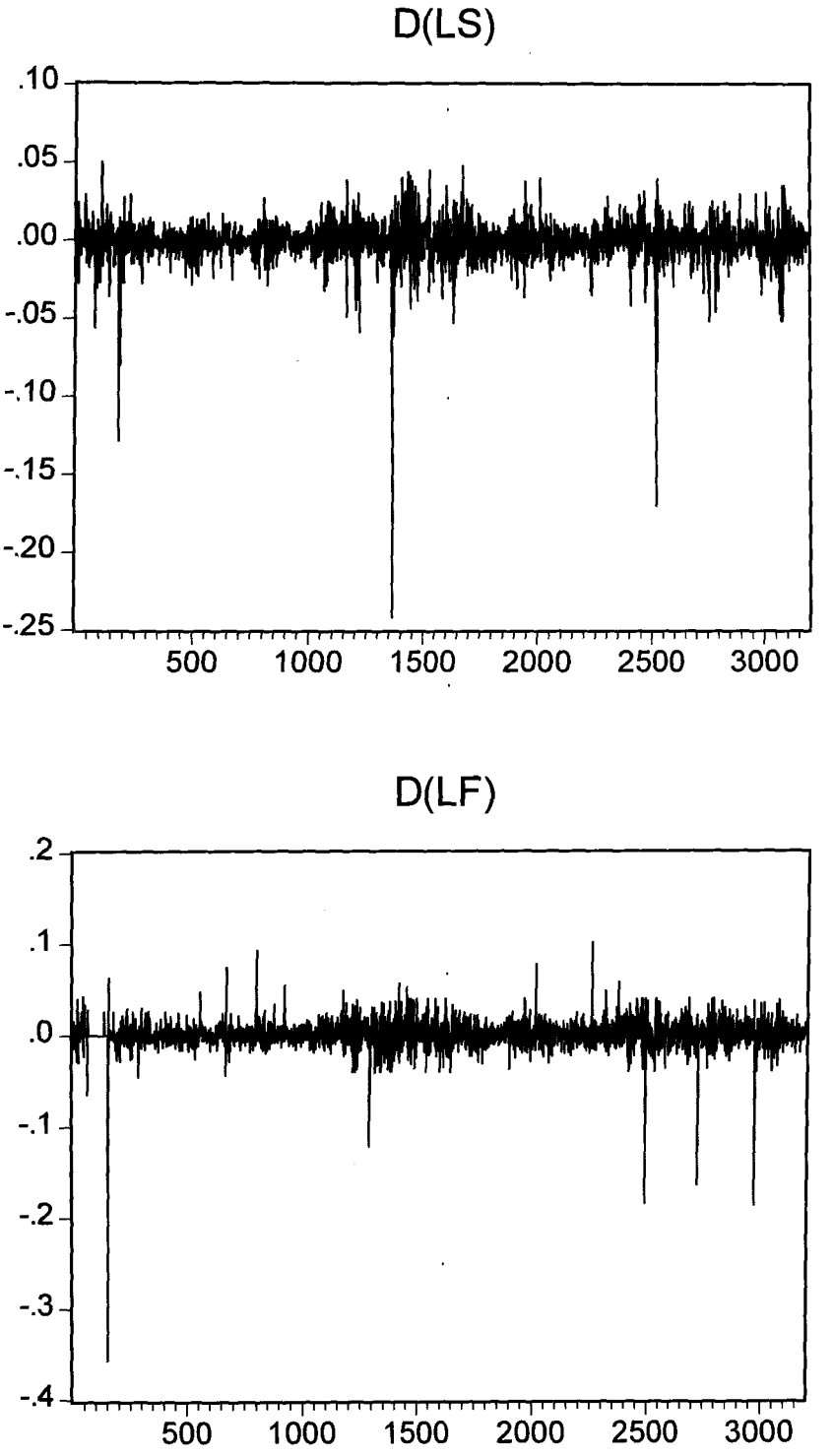


Figure 6.22: Volatility Clustering of Spot and Futures Commodity Market Returns of SOYA OIL

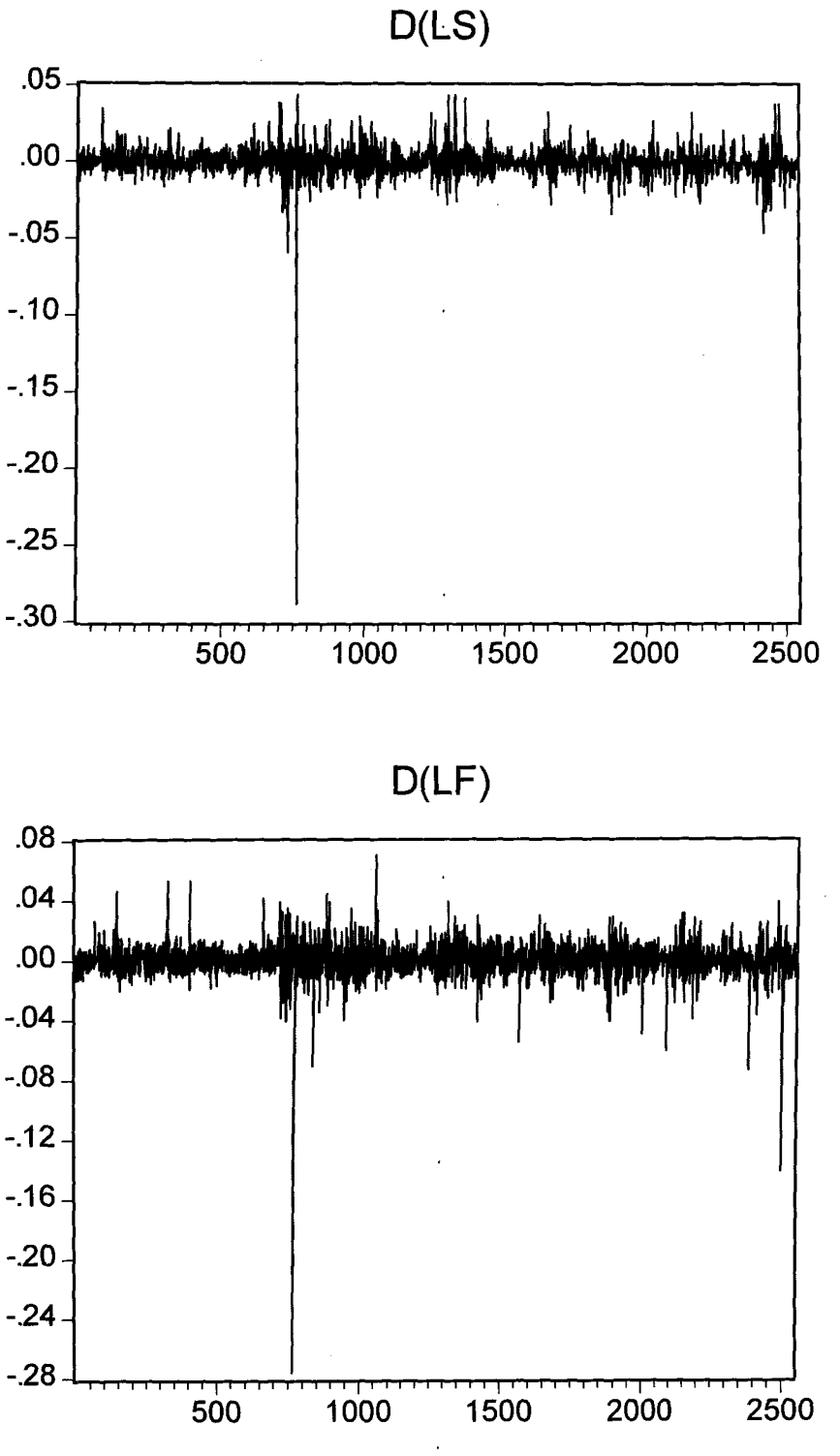


Figure 6.23: Volatility Clustering of Spot and Futures Commodity Market Returns of SUGAR

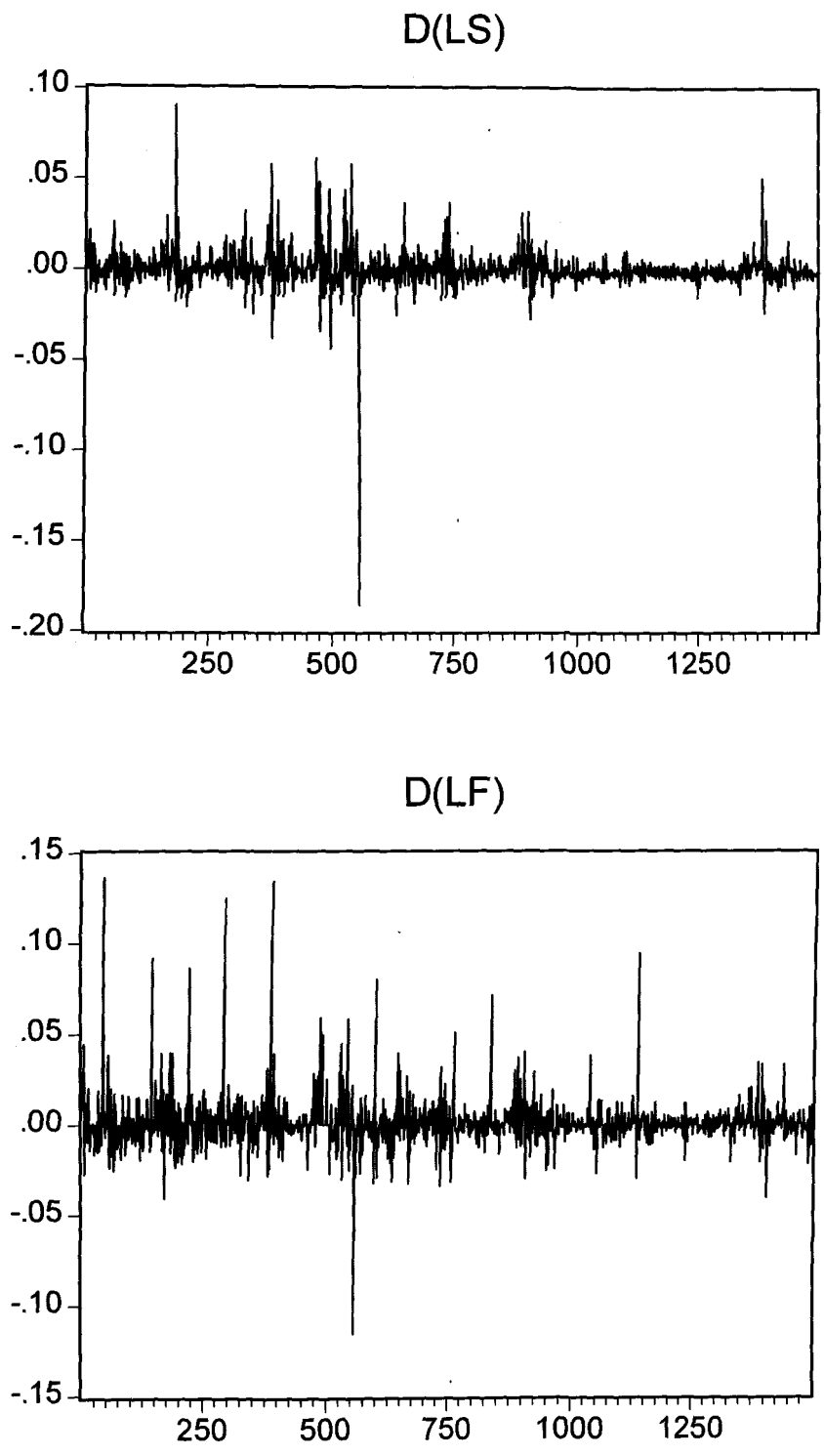


Figure 6.24: Volatility Clustering of Spot and Futures Commodity Market Returns of TURMERIC

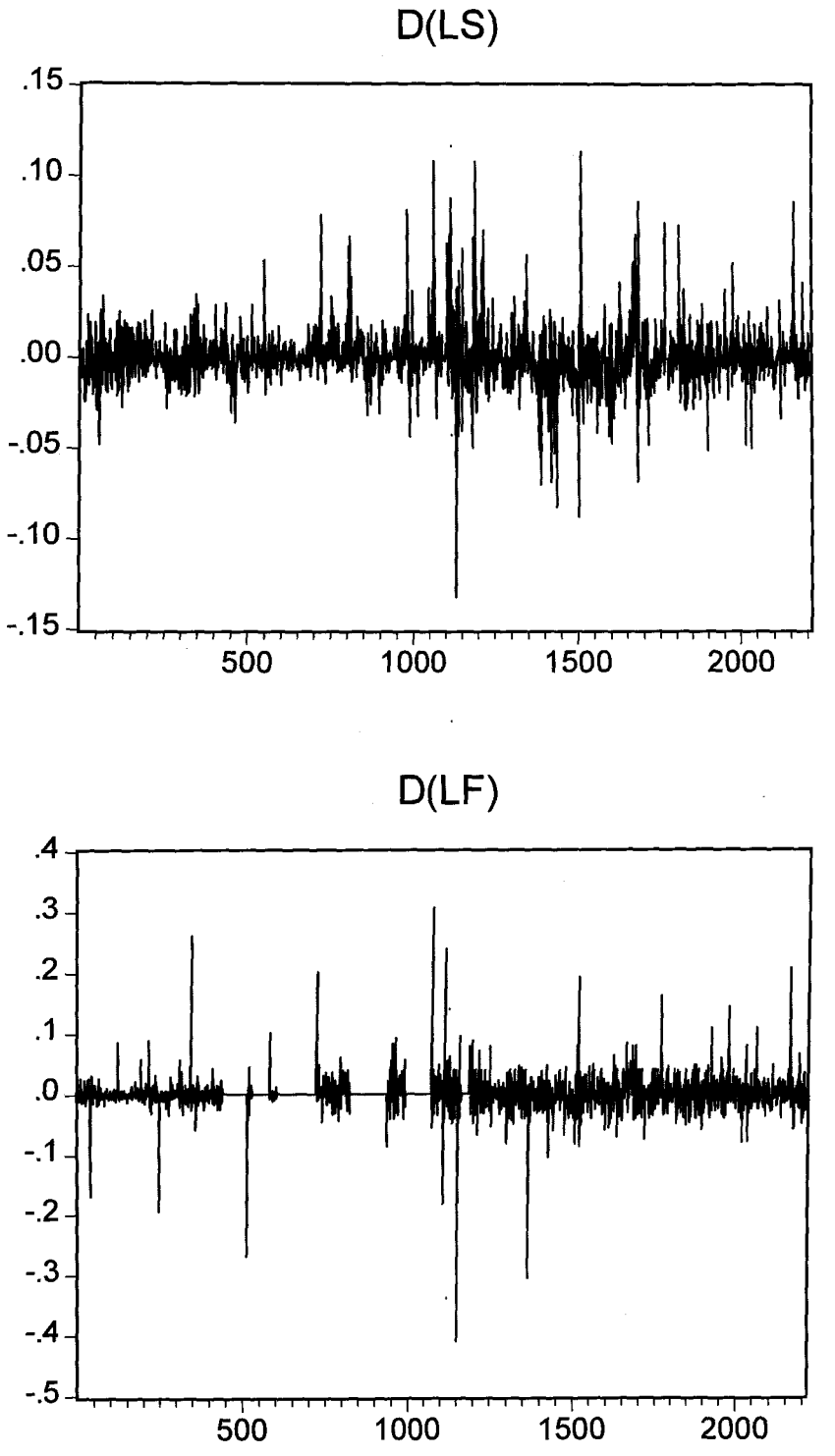


Figure 6.25: Volatility Clustering of Spot and Futures Commodity Market Returns of WHEAT

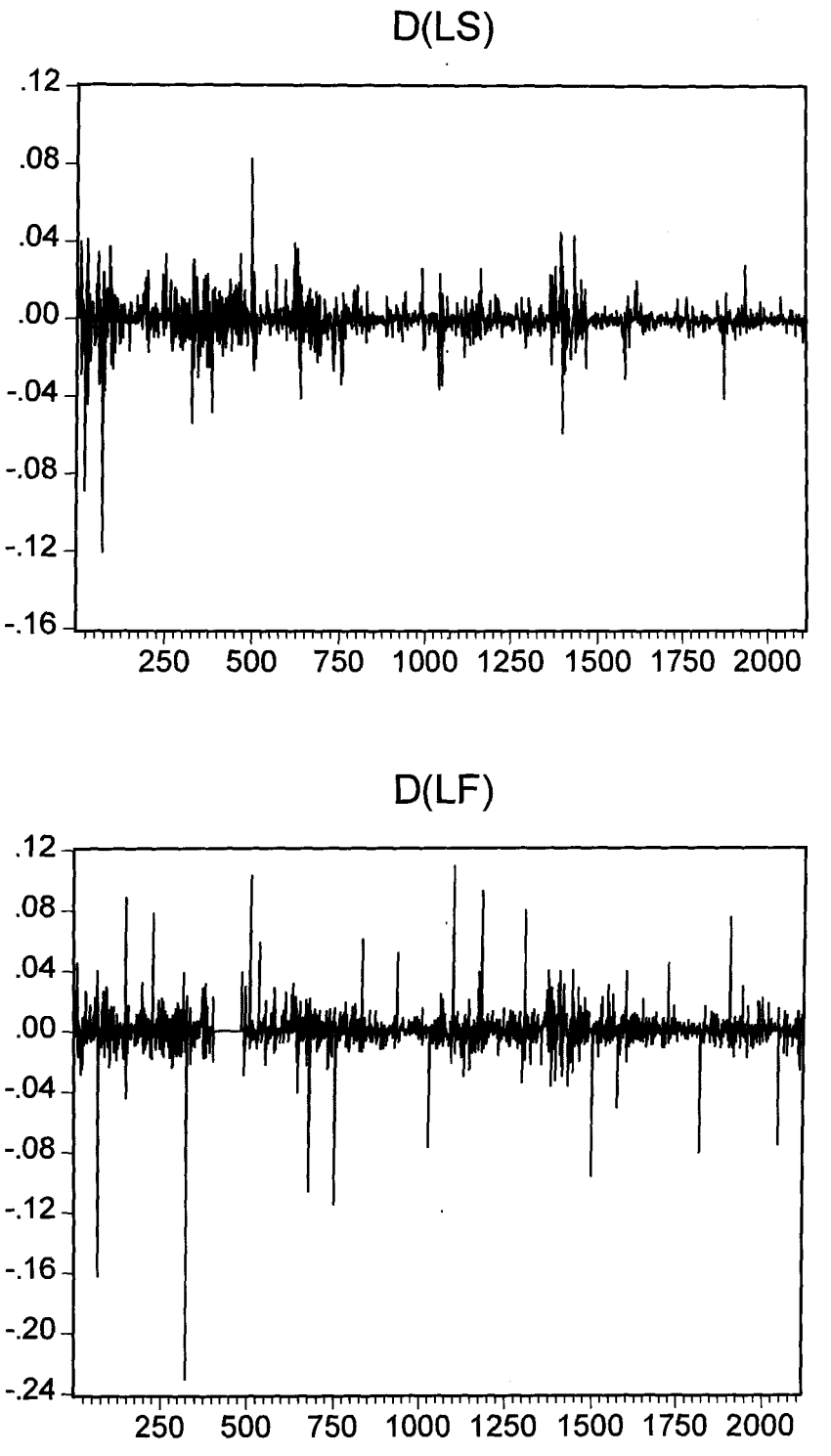


Figure 6.26: Volatility Clustering of Spot and Futures Commodity Market Returns of GOLD

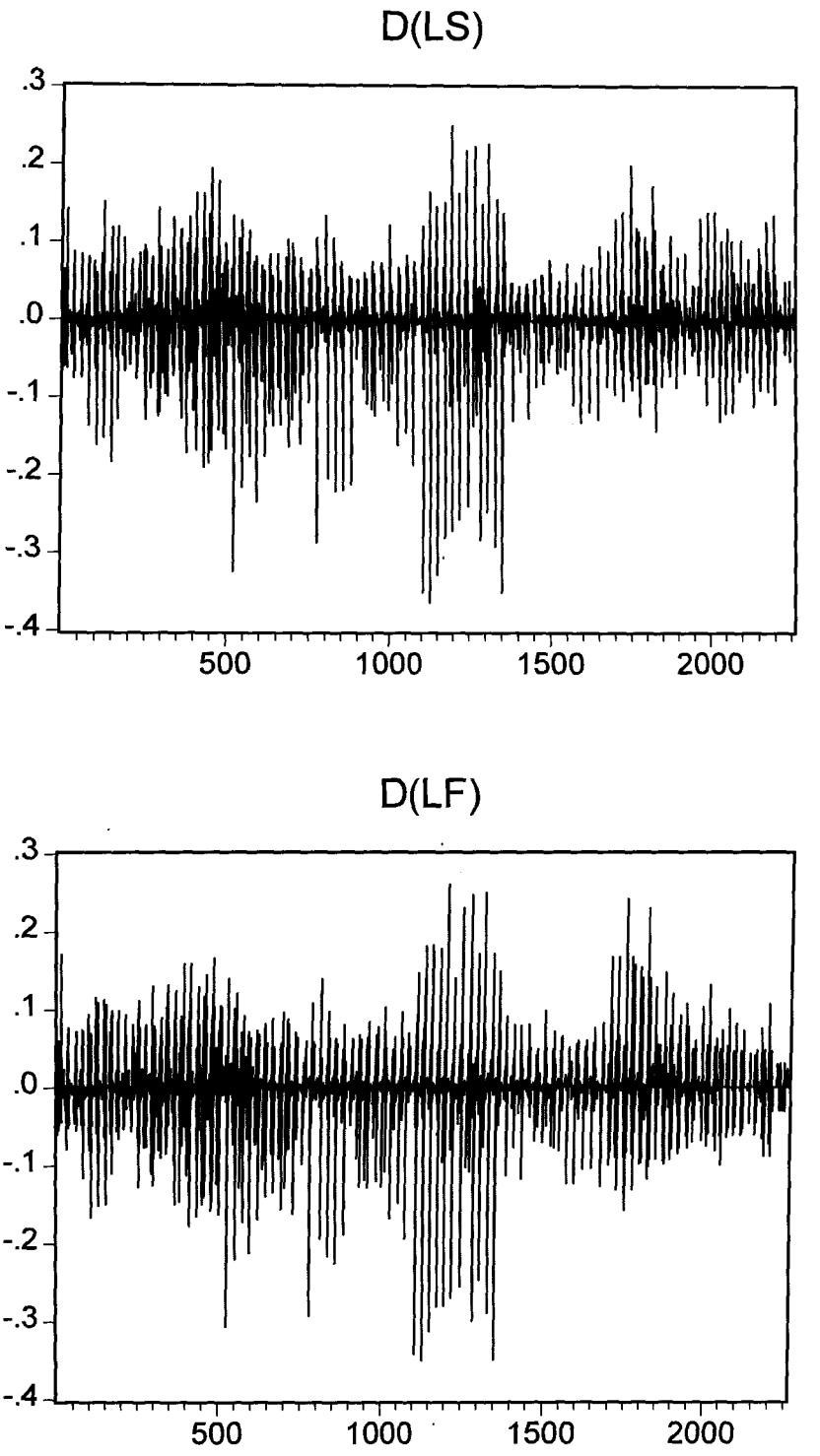


Figure 6.27: Volatility Clustering of Spot and Futures Commodity Market Returns of SILVER

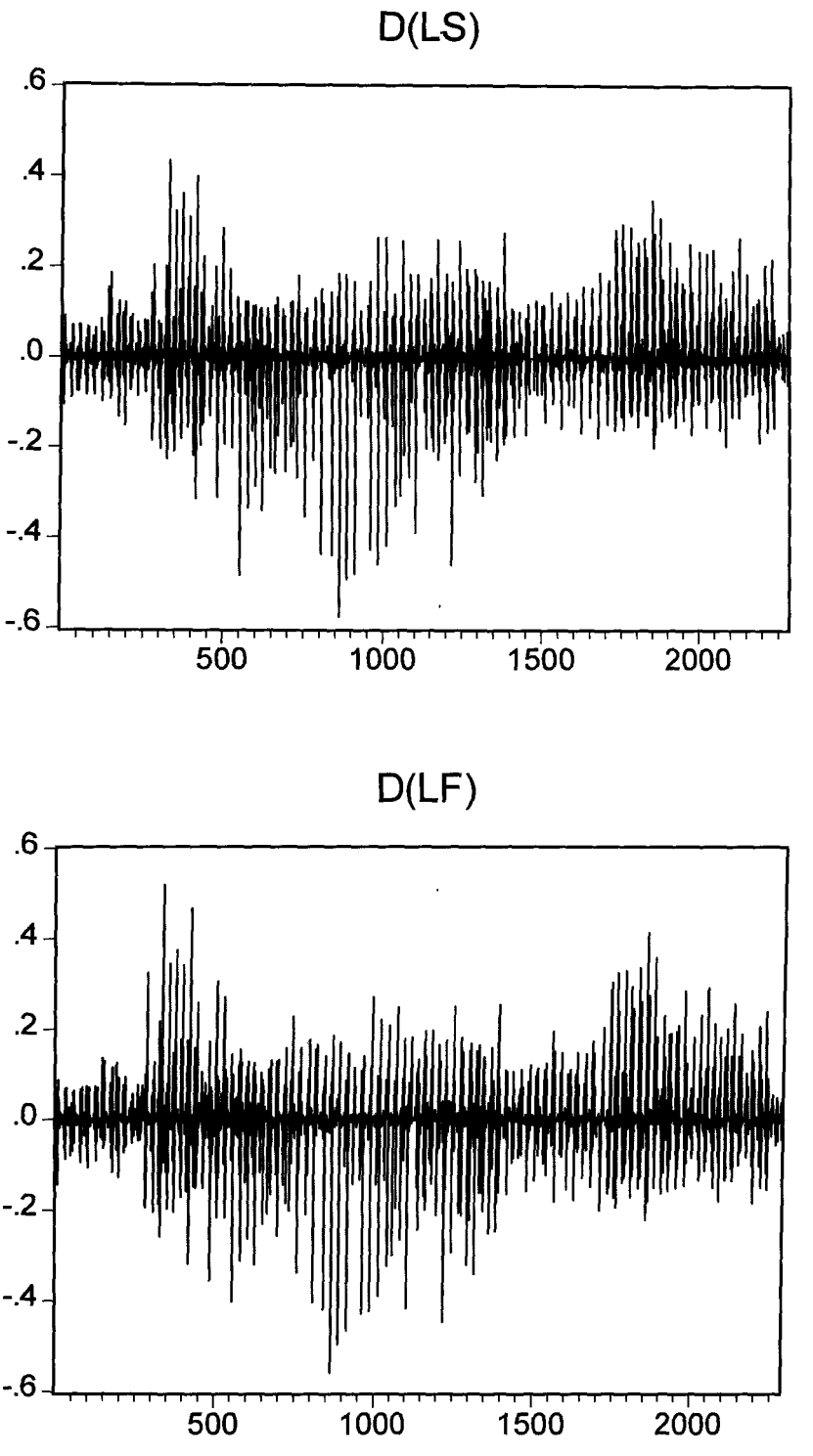


Figure 6.28: Volatility Clustering of Spot and Futures Commodity Market Returns of PLATINUM

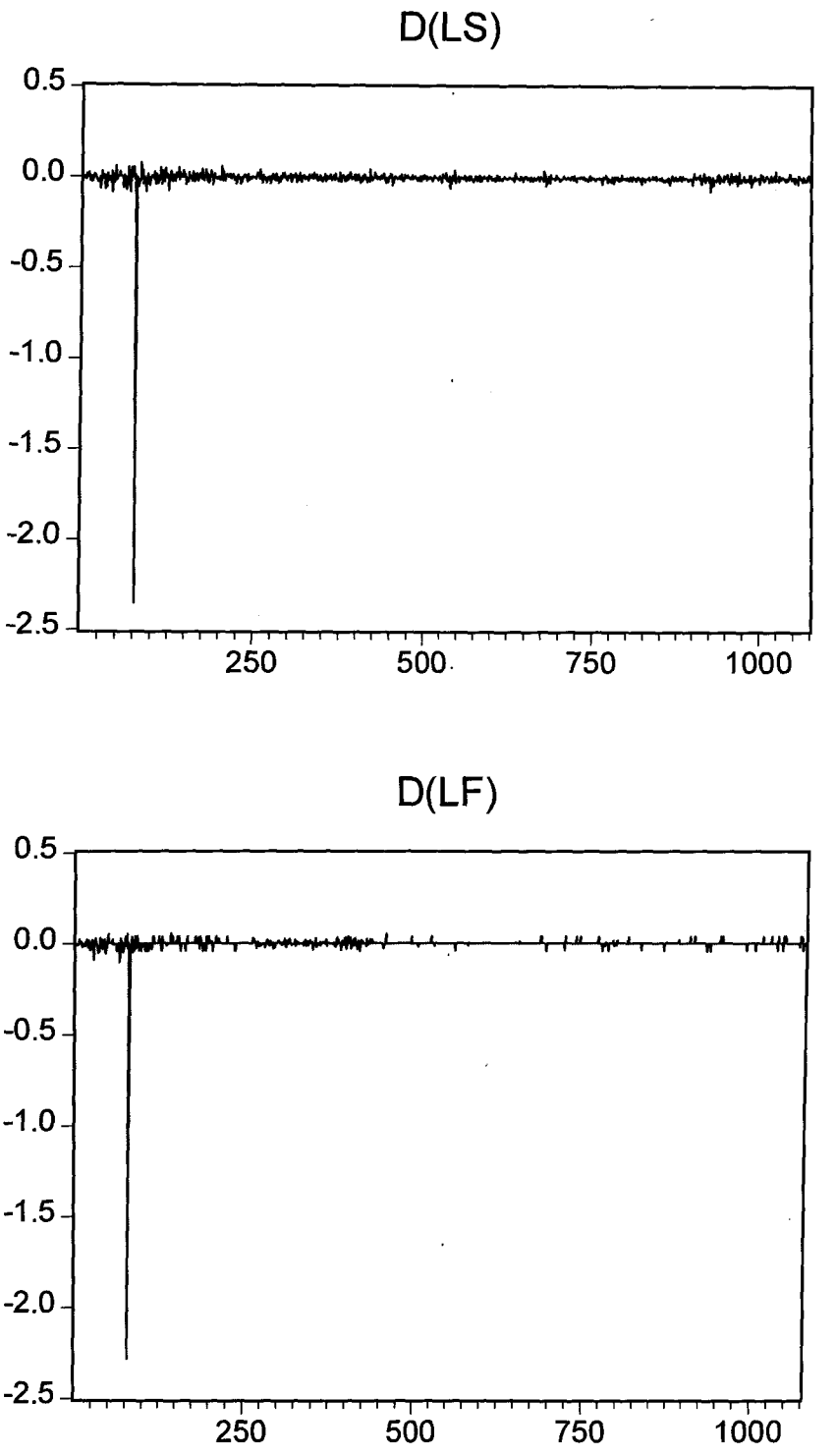


Figure 6.29: Volatility Clustering of Spot and Futures Commodity Market Returns of ATF

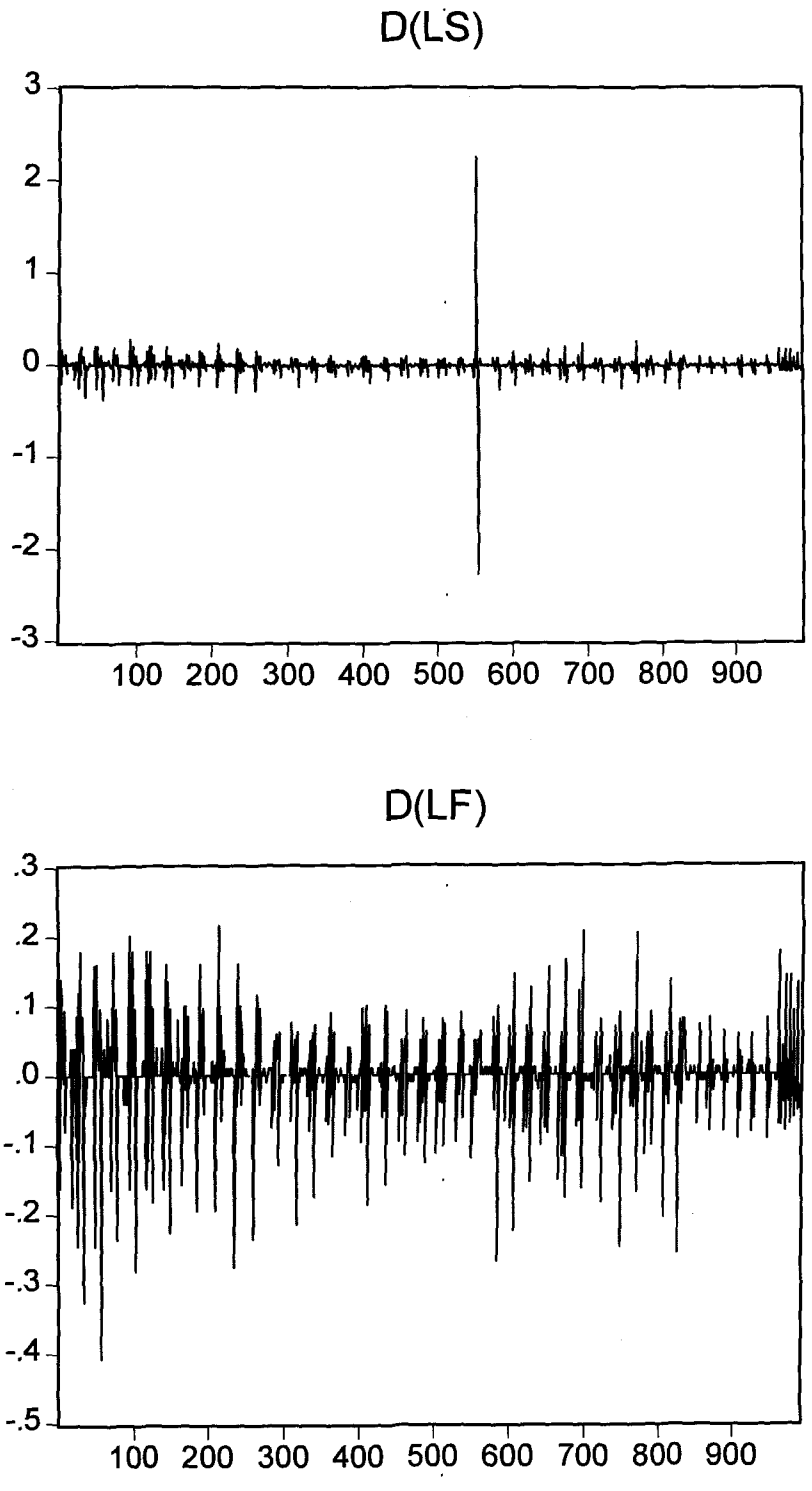


Figure 6.30: Volatility Clustering of Spot and Futures Commodity Market Returns of BRENT CRUDE OIL

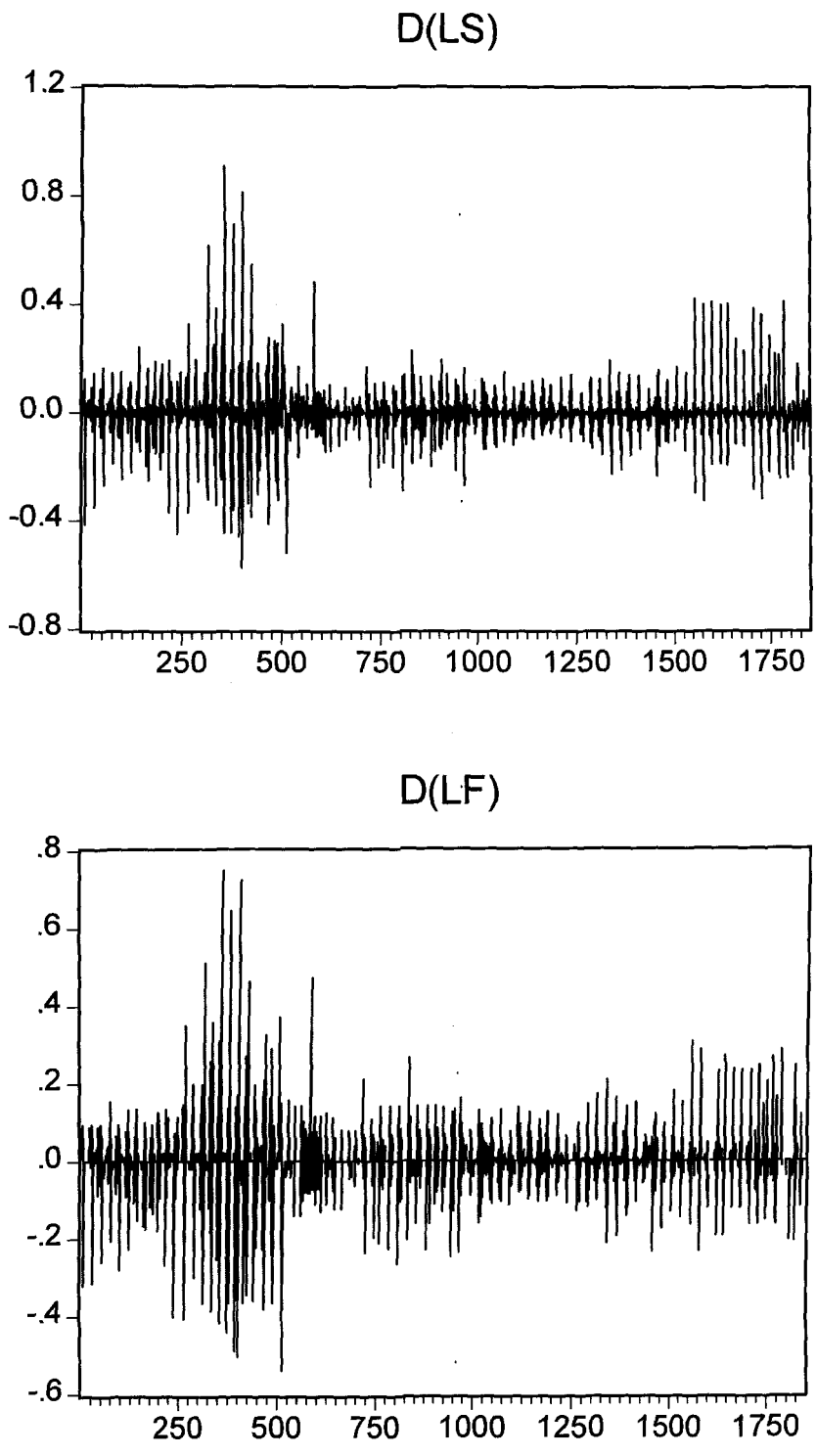


Figure 6.31: Volatility Clustering of Spot and Futures Commodity Market Returns of CRUDE OIL

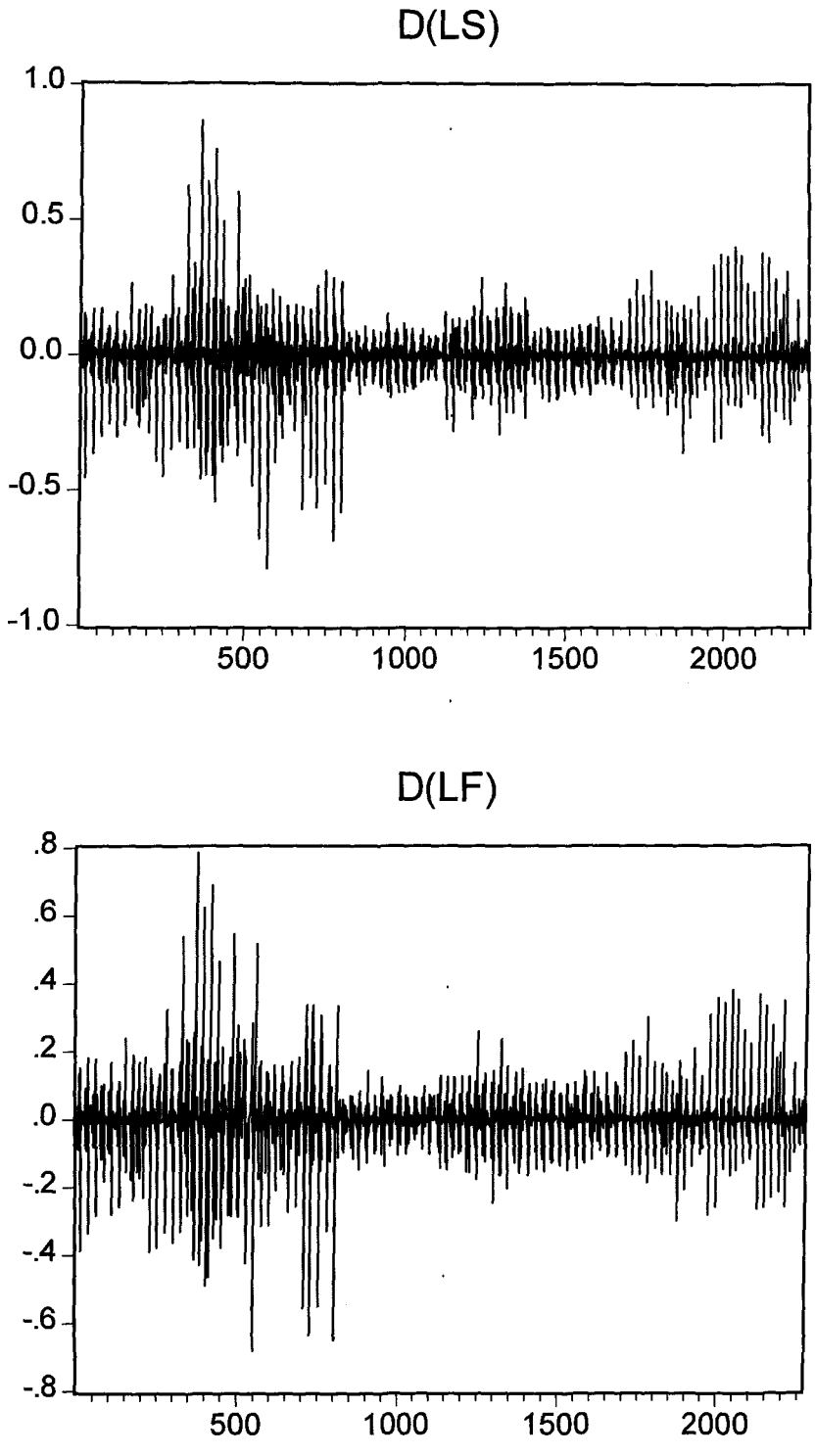


Figure 6.32: Volatility Clustering of Spot and Futures Commodity Market Returns of FURNACE OIL

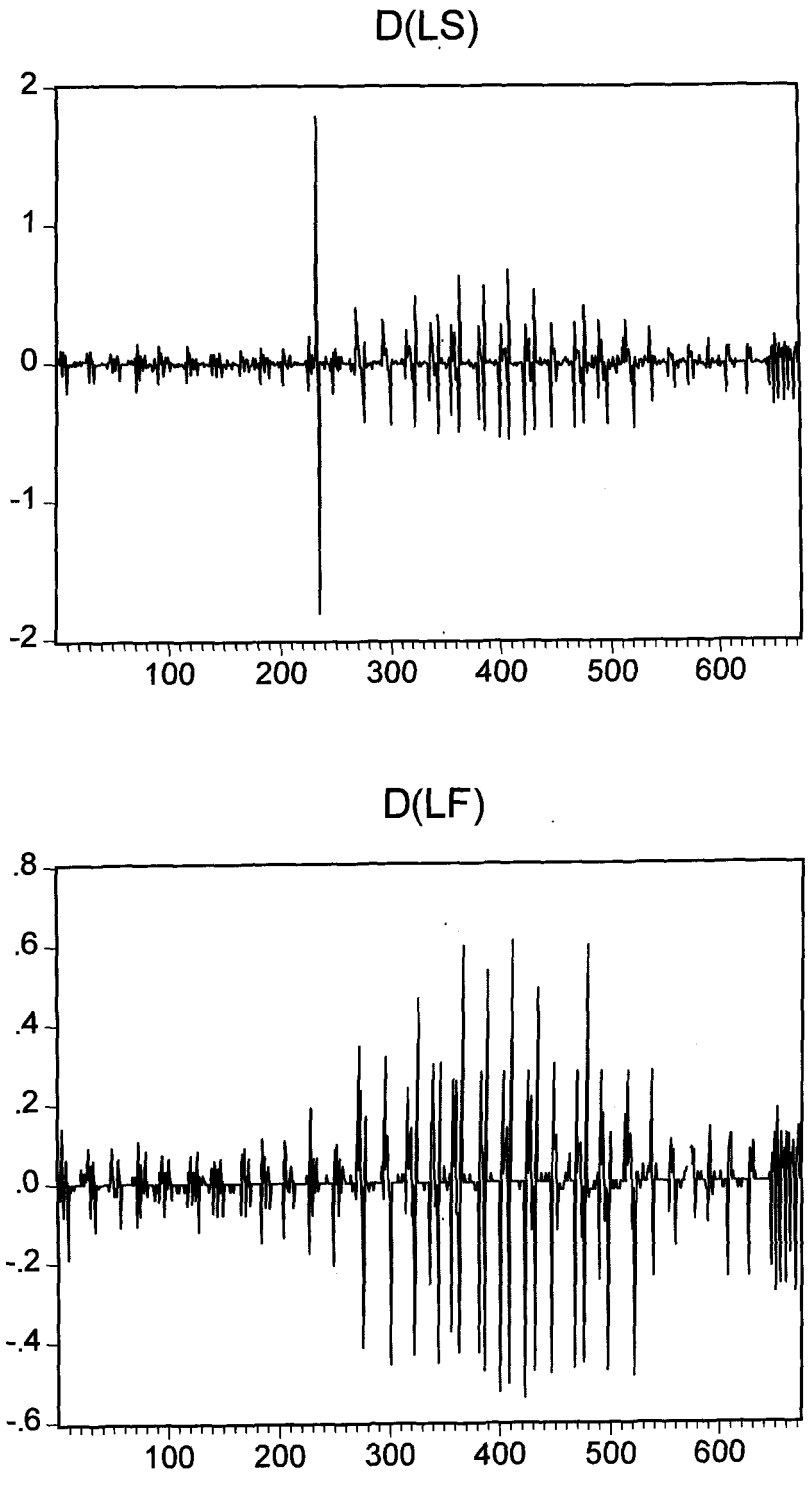


Figure 6.33: Volatility Clustering of Spot and Futures Commodity Market Returns of GASOLINE

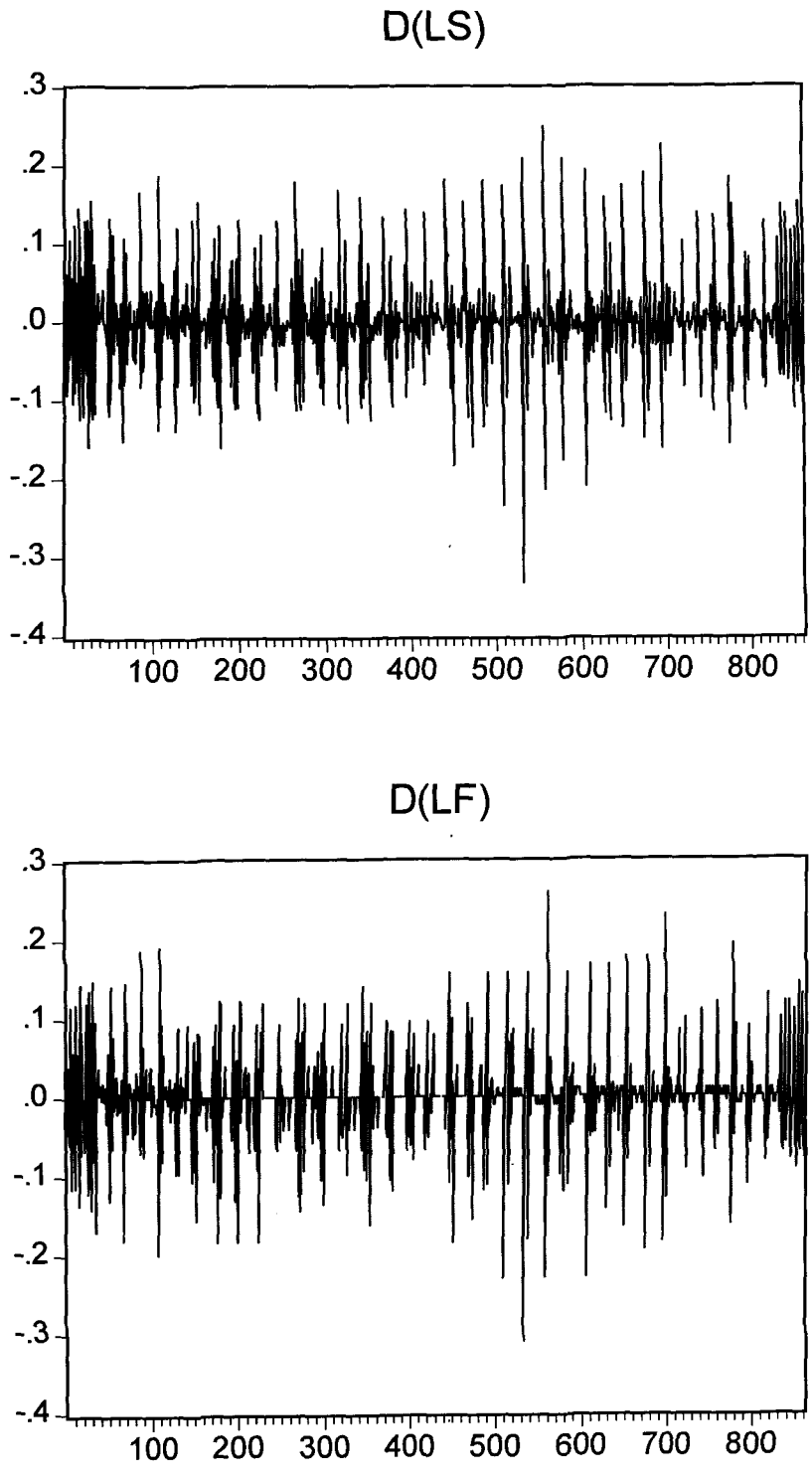


Figure 6.34: Volatility Clustering of Spot and Futures Commodity Market Returns of HEATING OIL

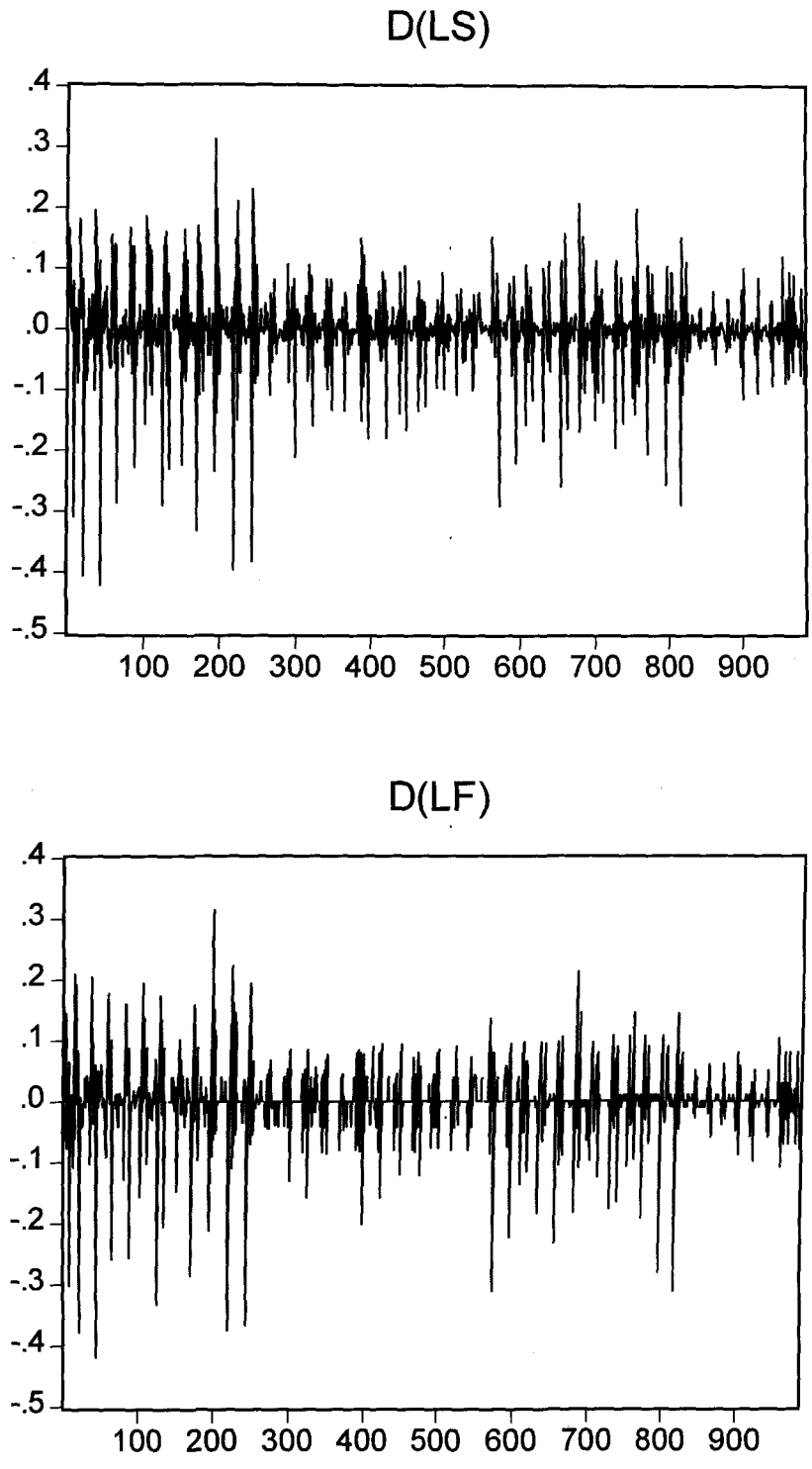


Figure 6.35: Volatility Clustering of Spot and Futures Commodity Market Returns of NATURAL GAS

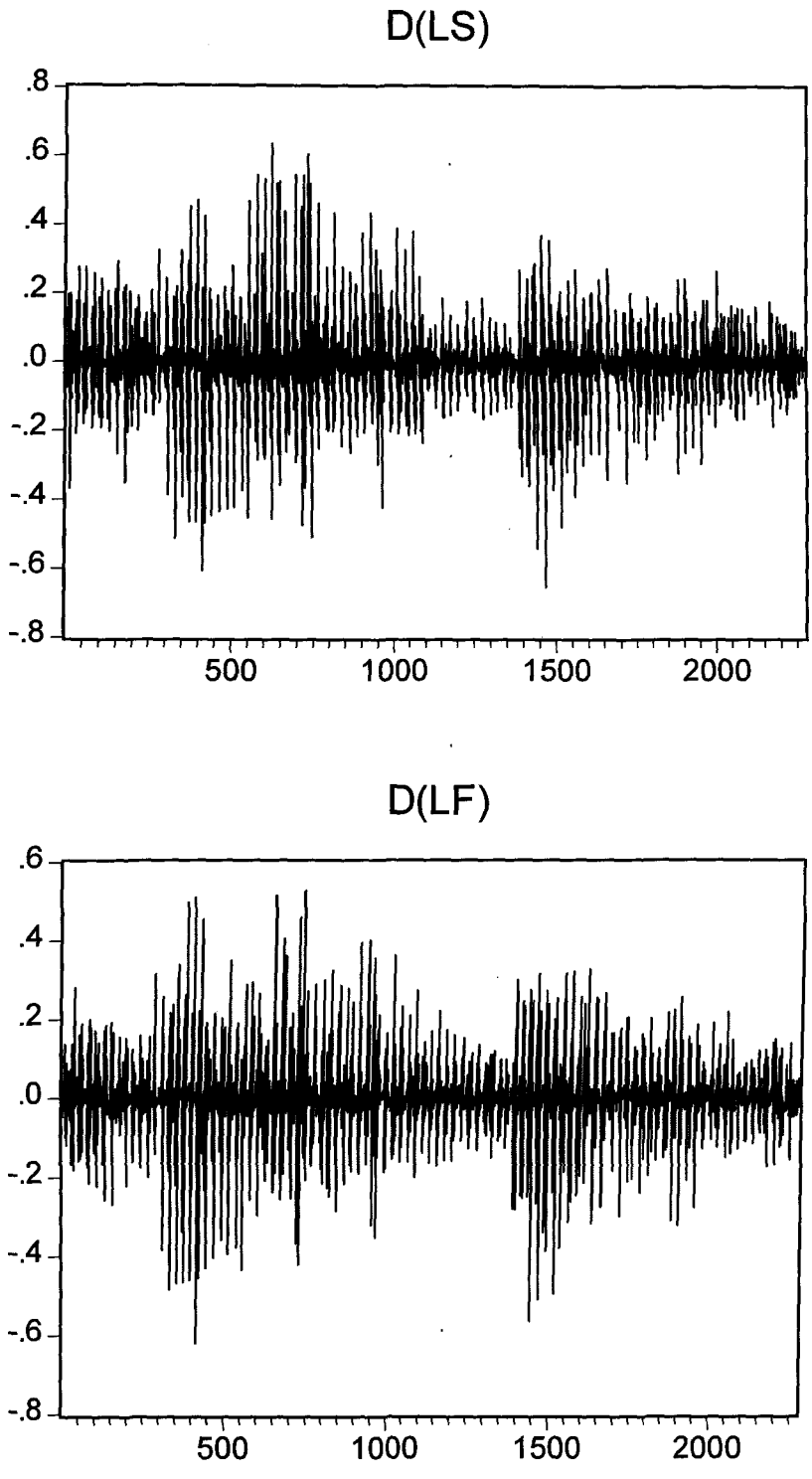


Figure 6.36: Volatility Clustering of Spot and Futures Commodity Market Returns of ALUMINIUM

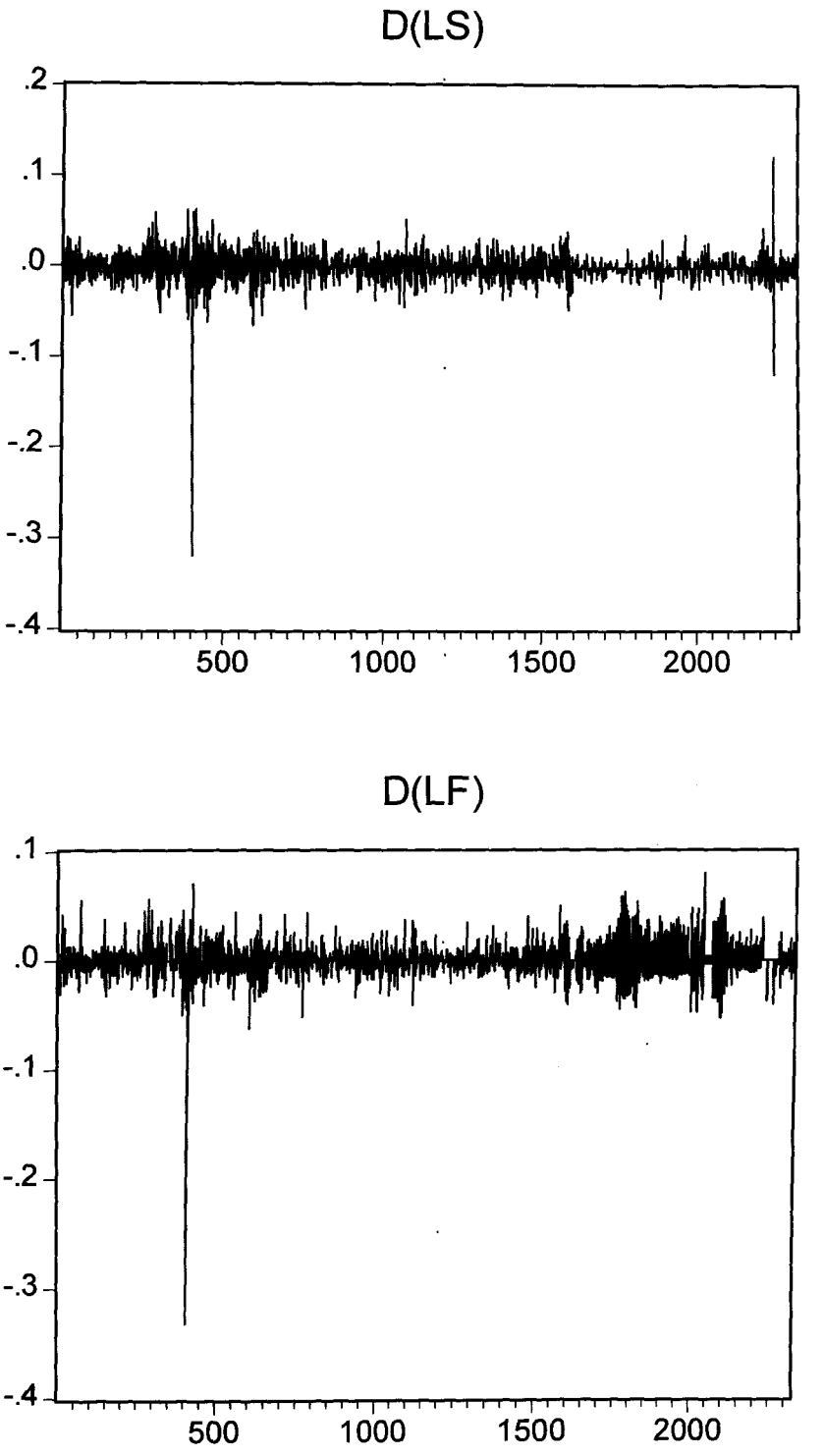


Figure 6.37: Volatility Clustering of Spot and Futures Commodity Market Returns of COPPER

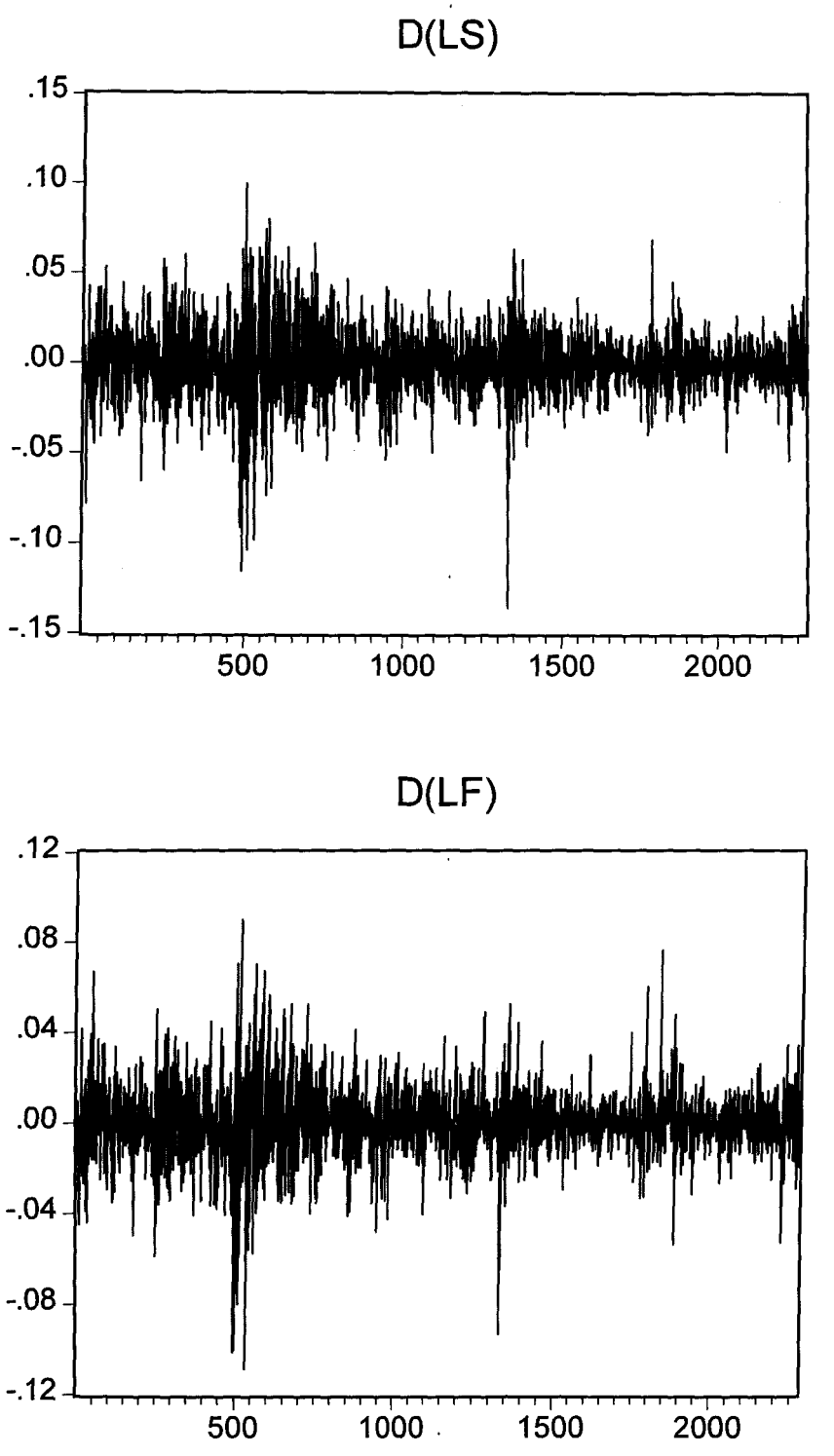


Figure 6.38: Volatility Clustering of Spot and Futures Commodity Market Returns of IRON ORE

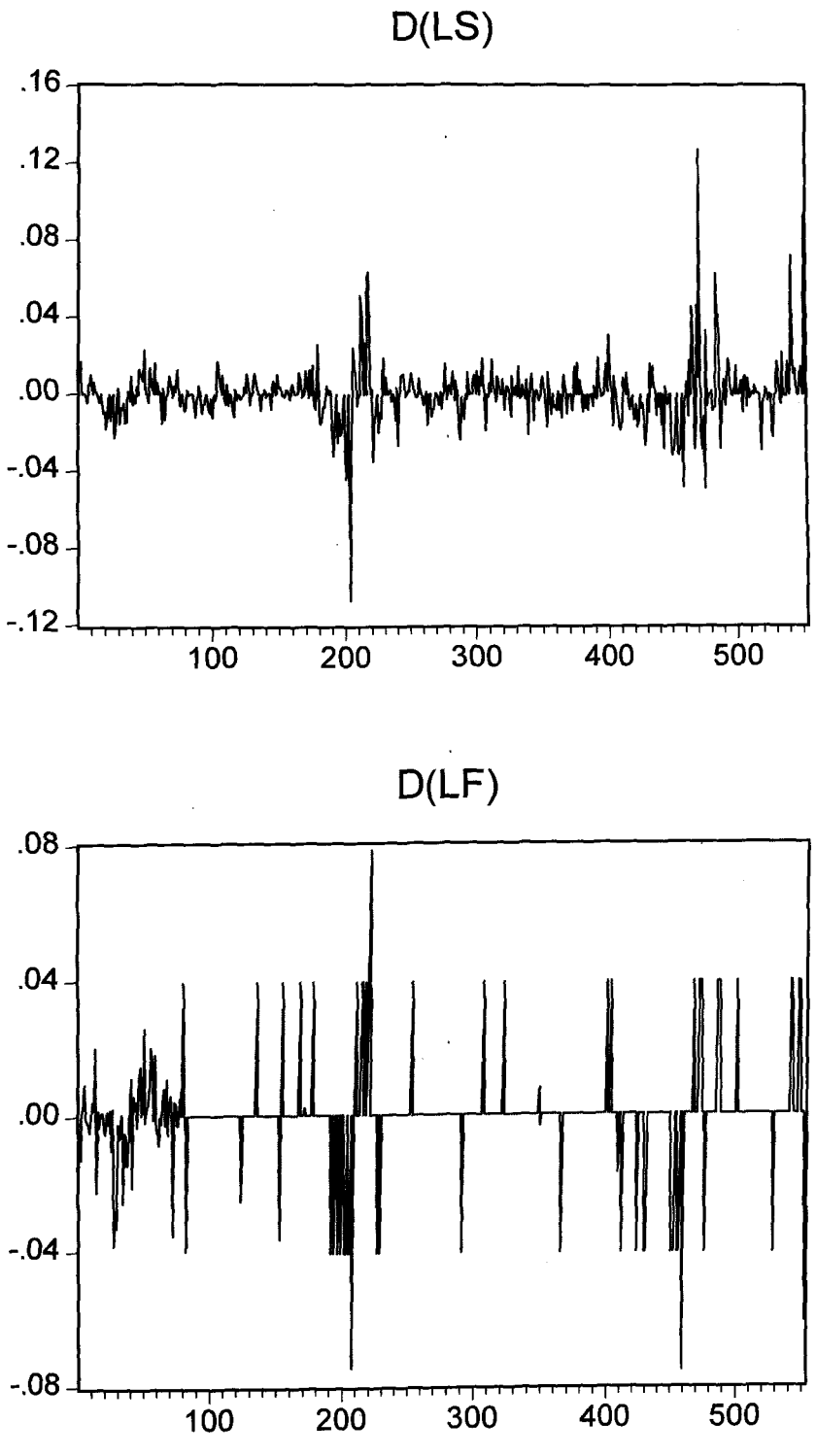


Figure 6.39: Volatility Clustering of Spot and Futures Commodity Market Returns of LEAD

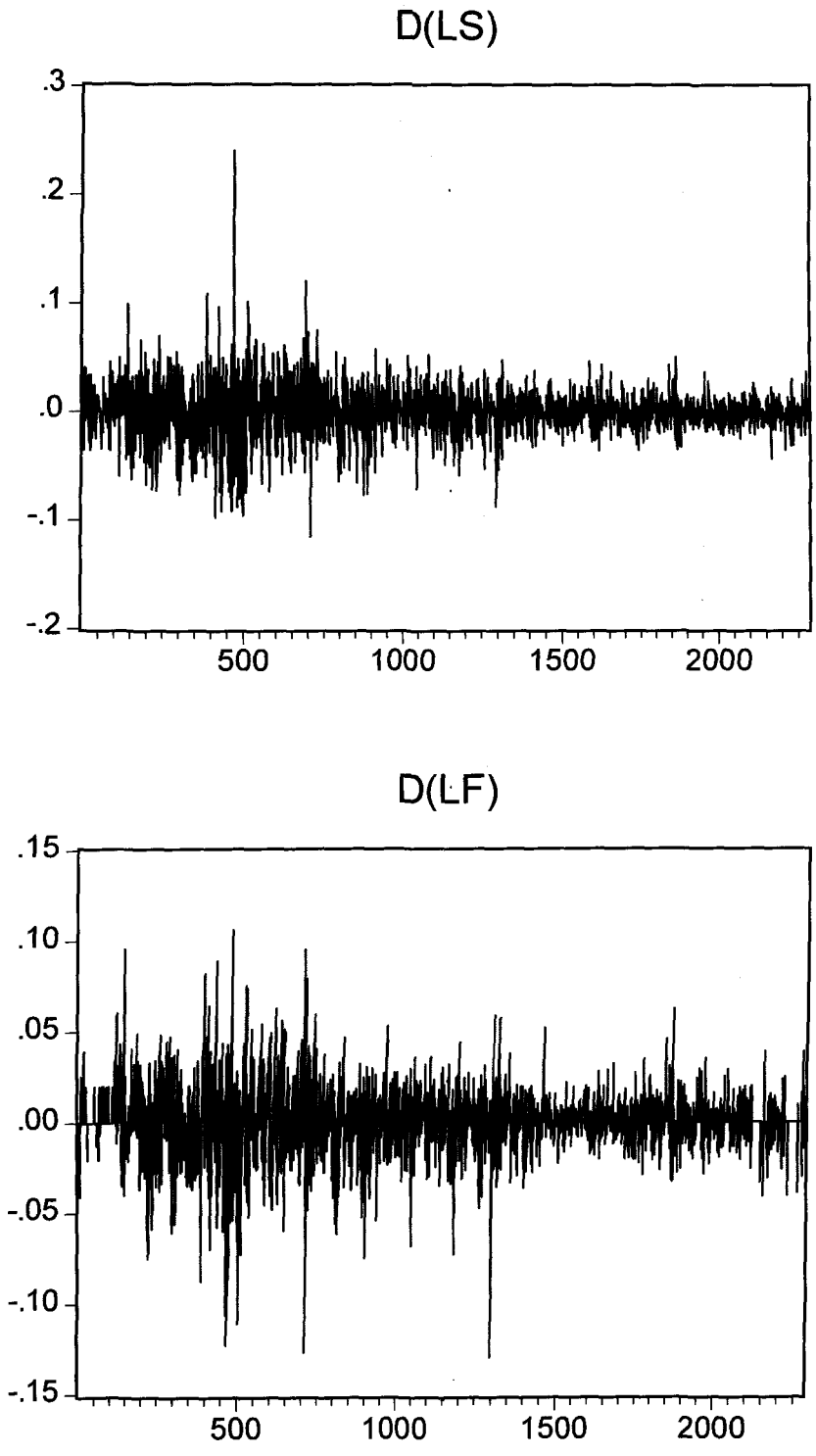


Figure 6.40: Volatility Clustering of Spot and Futures Commodity Market Returns of NICKEL

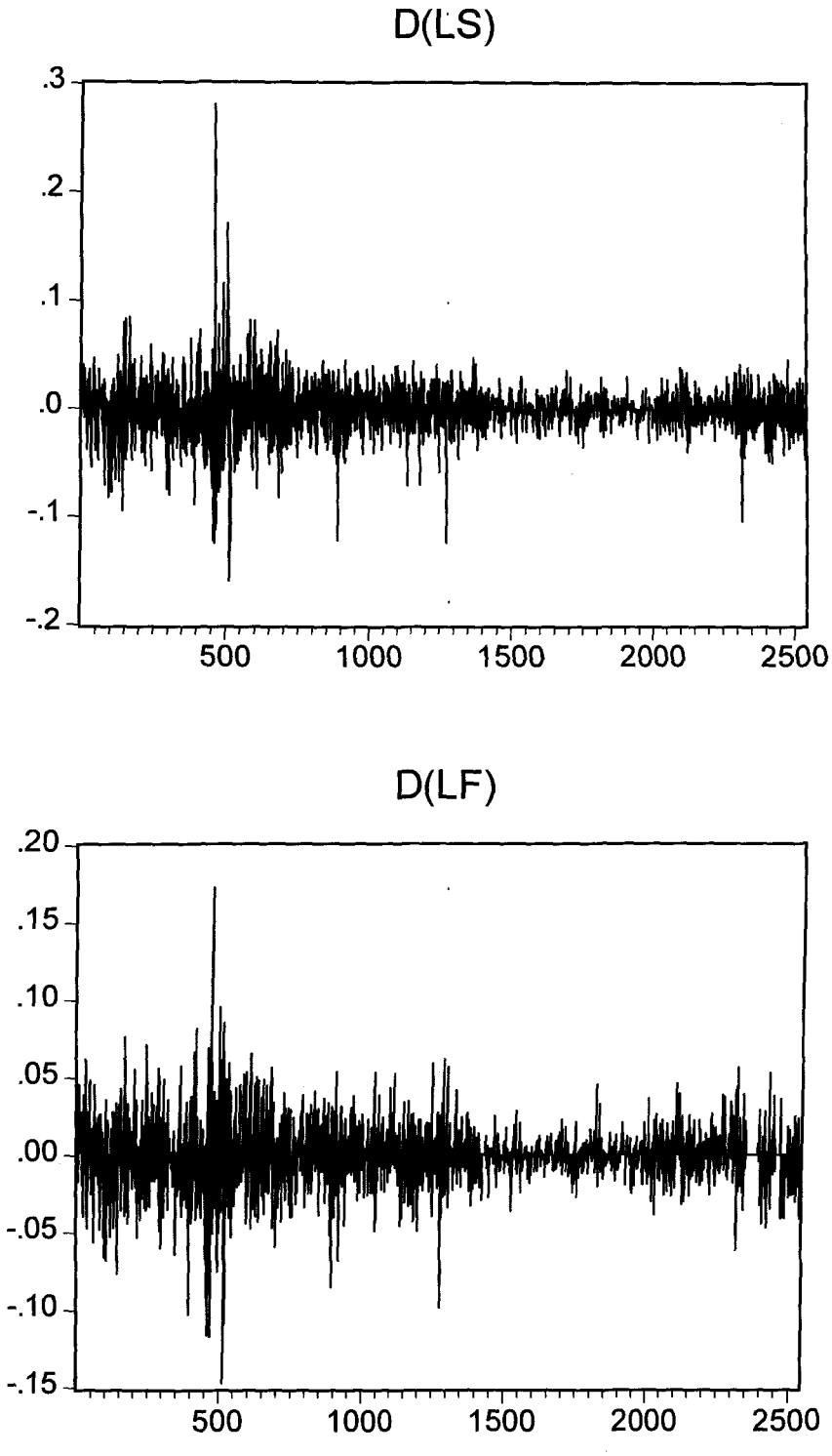


Figure 6.41: Volatility Clustering of Spot and Futures Commodity Market Returns of SPONGE IRON

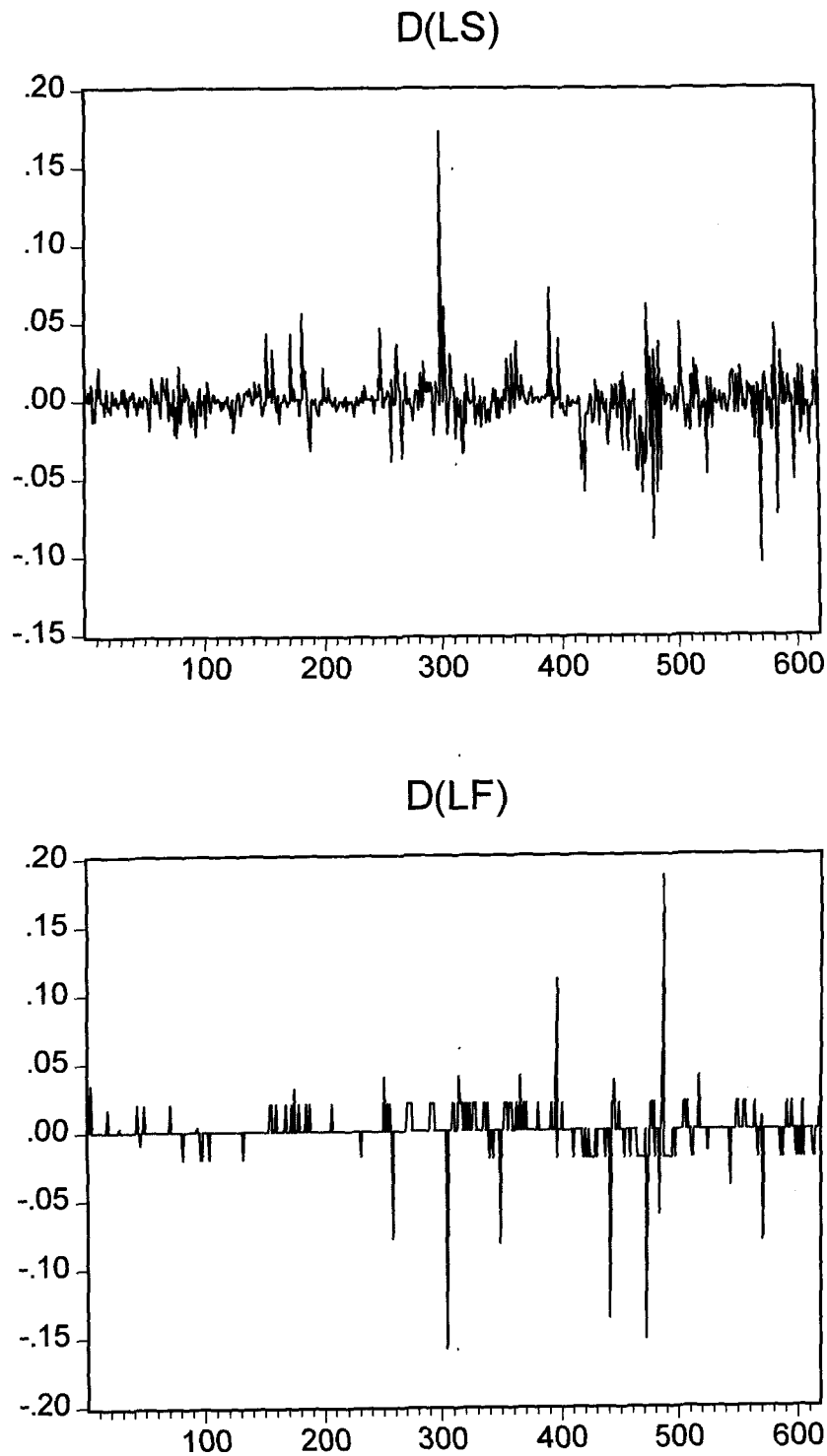


Figure 6.42: Volatility Clustering of Spot and Futures Commodity Market Returns of STEEL FLAT

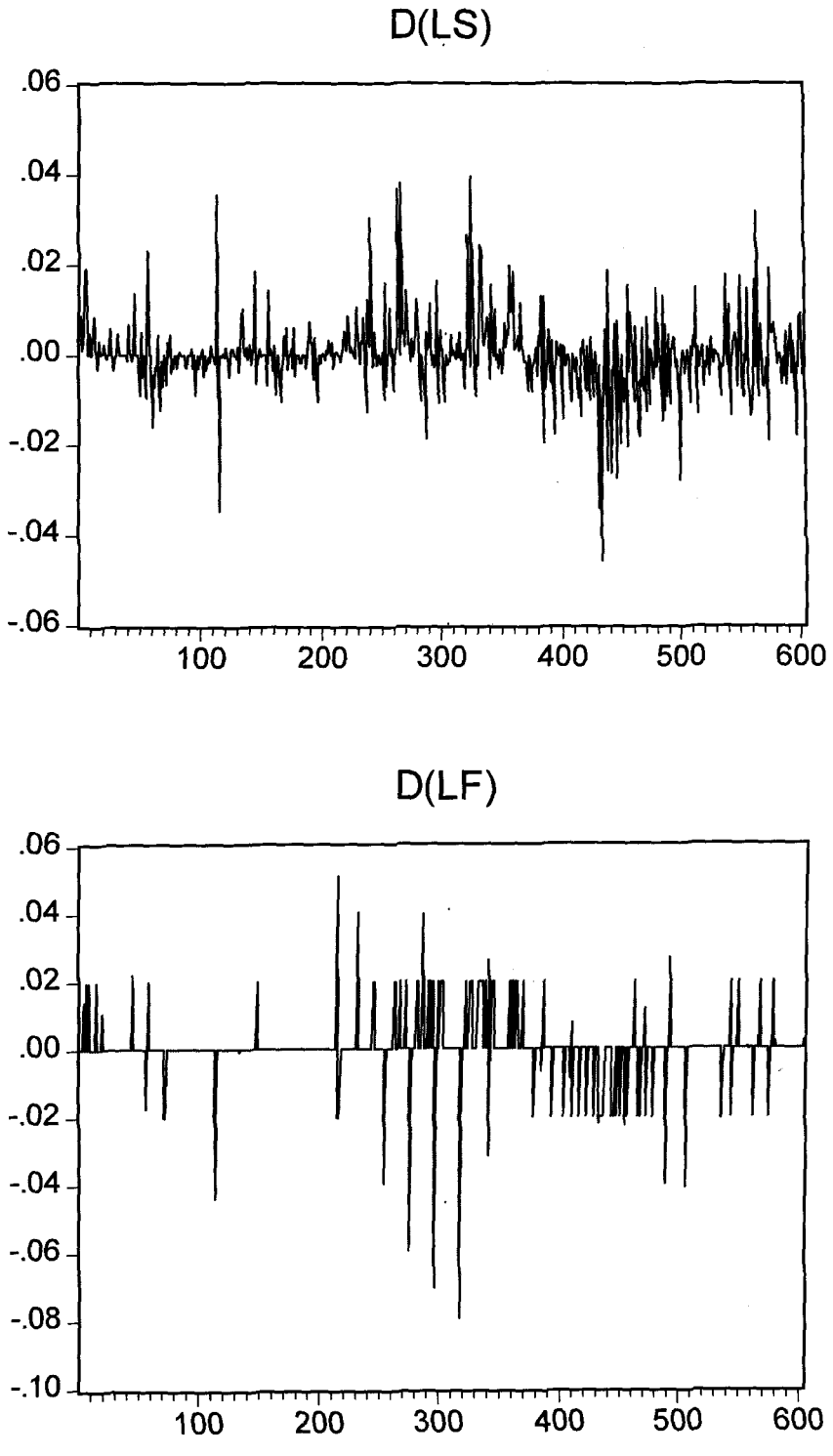


Figure 6.43: Volatility Clustering of Spot and Futures Commodity Market Returns of THERMAL COAL

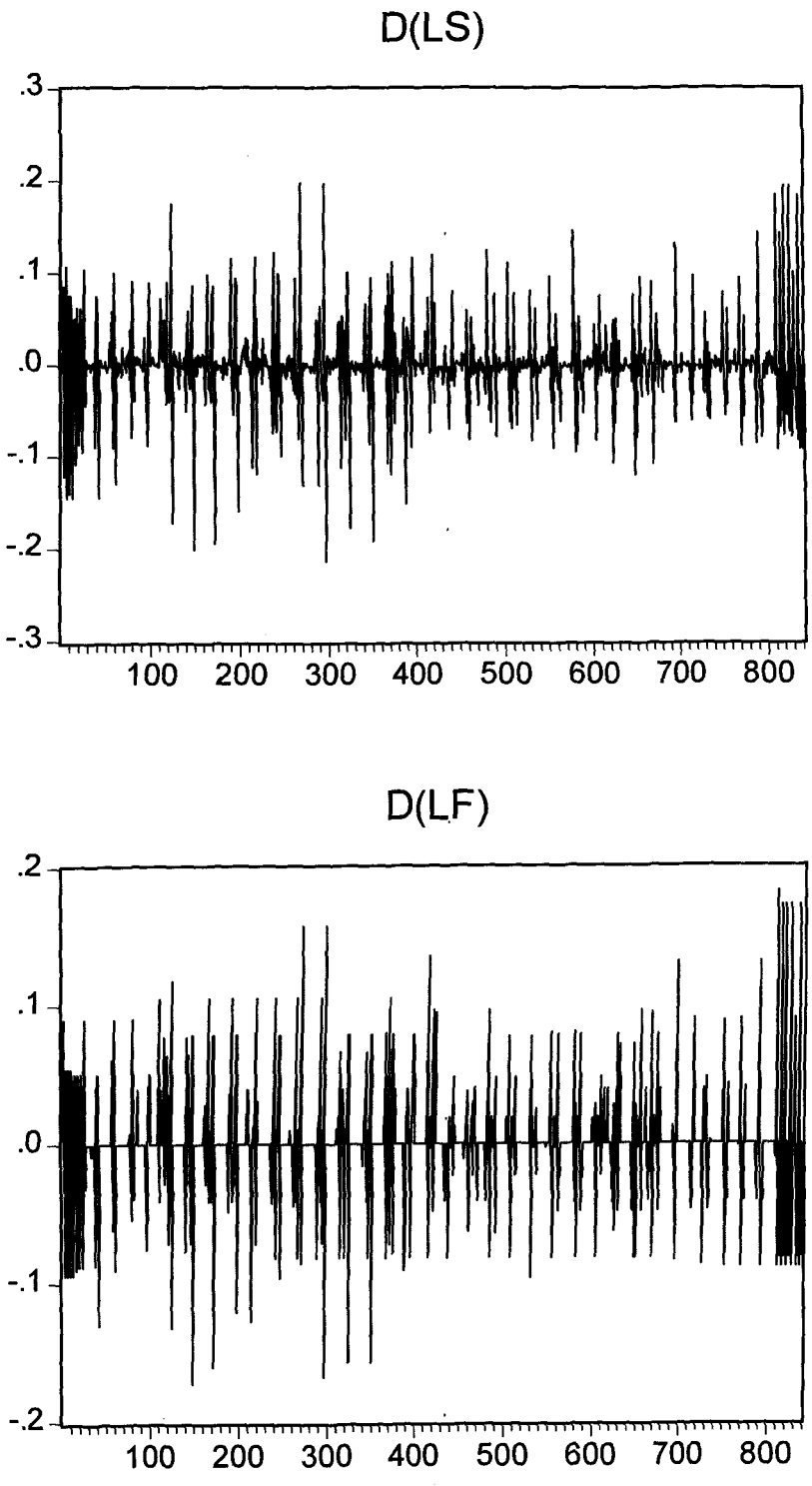


Figure 6.44: Volatility Clustering of Spot and Futures Commodity Market Returns of TIN

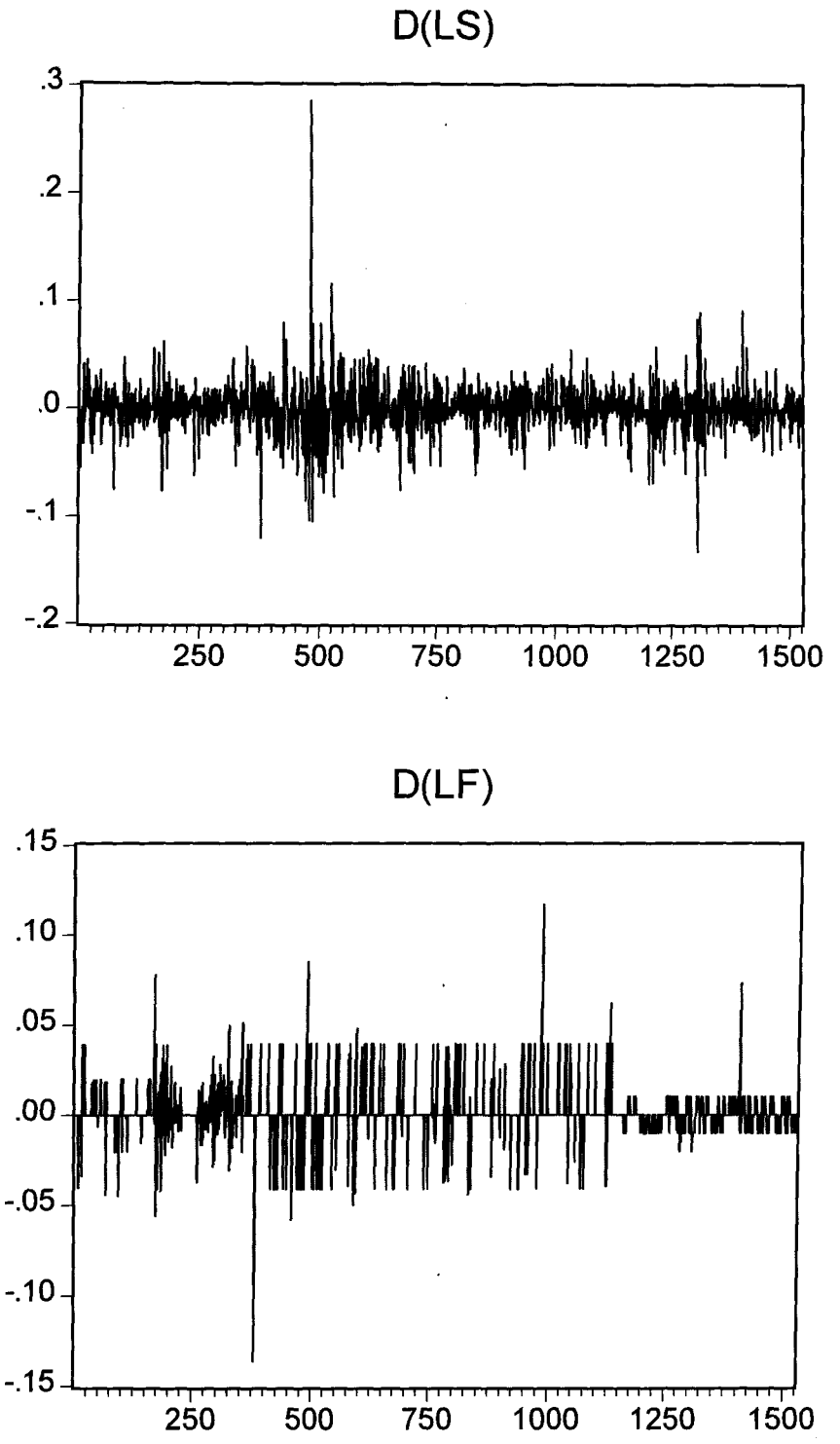
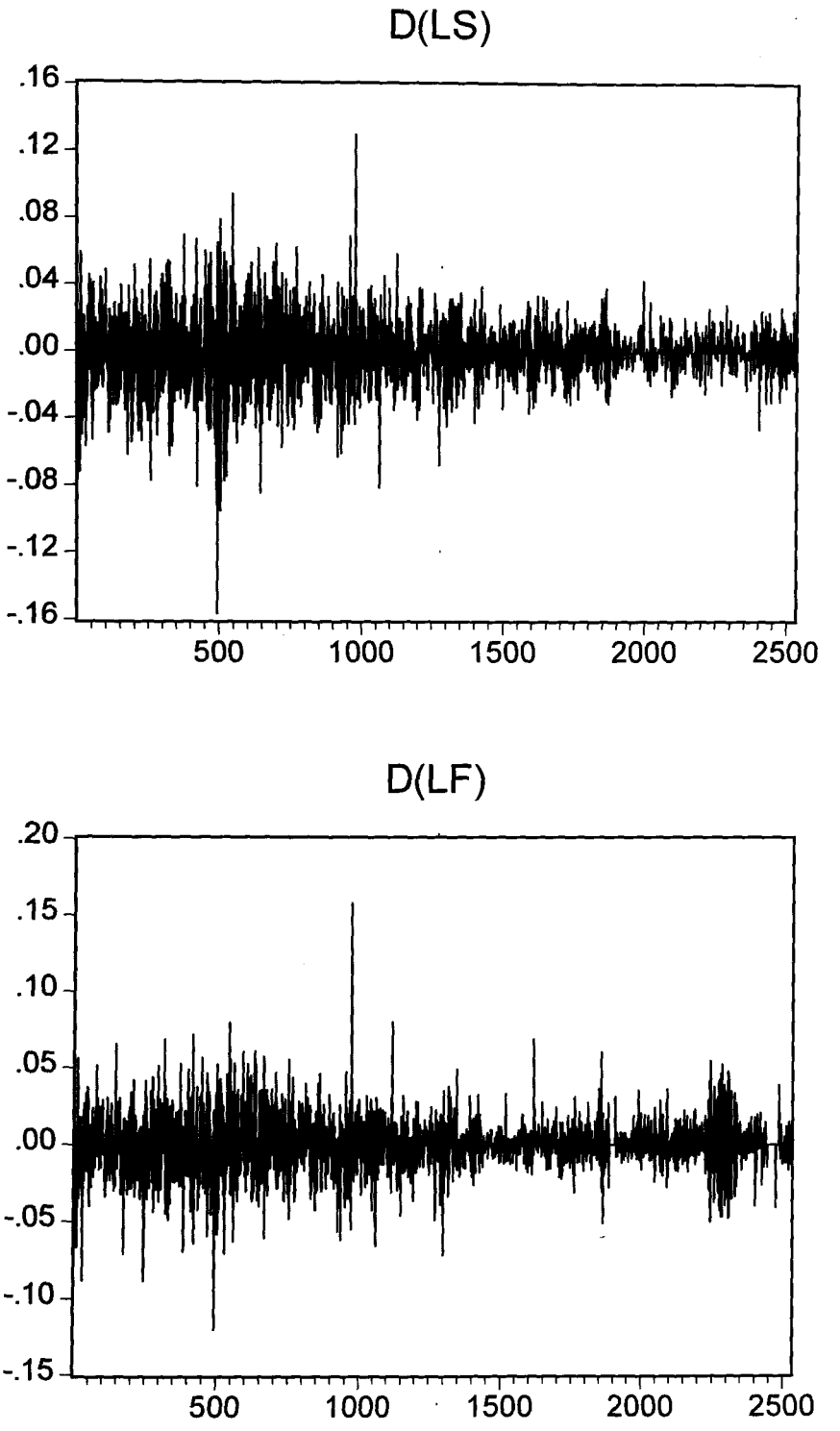


Figure 6.45: Volatility Clustering of Spot and Futures Commodity Market Returns of ZINC



6.7 Bivariate EGARCH Model:

The Bivariate EGARCH model as shown in table- 6.6 is used to estimate and verify the presence of volatility spillover systems that caused futures and spot prices in the commodities representing Bullion, Agriculture, Energy and Metal.

Table- 6.6 Results of Volatility Spillover in Individual Commodities Spot and Futures Markets

Name of the Stocks	Market	ω_i	ψ_i	α_i	γ_i	τ_i	ARCH-LM Statistics	Inference
AGRICULTURE								
BARLEY	Spot	-0.138* (-8.843)	-2.670* (-18.81)	0.665* (33.04)	0.768* (10.89)	-0.399* (-22.95)	0.0019 [0.9650]	
	Futures	0.094* (6.913)	-0.987* (-12.08)	0.892* (84.75)	0.089 (1.495)	-0.027** (-2.357)	6.6692 [0.4137]	F→S
CASTOR SEEDS	Spot	0.036** (2.302)	-6.146* (-27.92)	0.220* (7.344)	0.749* (4.30)	-0.330* (-18.01)	0.0088 [0.9249]	
	Futures	0.083** (5.976)	-0.287* (-7.885)	0.971* (23.38)	0.181 (01.49)	-0.074* (-8.770)	0.0081 [0.9279]	F→S
CHANNA	Spot	0.0338 (1.618)	-0.7681* (-4.342)	0.9085* (37.16)	0.1890* (5.951)	-0.035** (-1.975)	1.0388 [0.3084]	
	Futures	0.034** (1.992)	-9.144* (-60.89)	0.128* (5.886)	0.0861 (1.651)	-0.422* (-14.88)	0.1690 [0.6810]	F→S
CHILLI	Spot	0.0862* (3.892)	-1.7767* (-6.840)	0.8178* (25.23)	0.3333* (8.251)	-0.0213* (-2.963)	0.6810 [0.2777]	
	Futures	0.0423** (1.970)	-1.2372* (-8.224)	0.8637* (45.05)	0.0356 (1.509)	-0.0194** (-2.036)	1.6171 [0.2039]	F→S
	Spot	0.0429**	-2.259*	0.7547*	0.3905*	-0.0156*	1.2602	F↔S

CORRIANDER		(2.268)	(-12.89)	(31.74)	(18.05)	(-2.939)	[0.2793]	
	Futures	0.0762* (5.301)	-0.9088* (-6.908)	0.8913* (55.57)	0.1897* (9.692)	-0.0318* (-2.808)	1.6563 [0.1166]	
COTTON SEED OIL CAKE	Spot	0.0599* (3.916)	-1.1850* (-7.836)	0.8704* (49.34)	0.2211* (8.961)	-0.0559* (-4.483)	0.5449 [0.4606]	
	Futures	0.0603* (3.706)	-1.4963* (-8.092)	0.8398* (36.87)	0.2488* (9.078)	-0.0788* (-4.924)	0.2127 [0.6448]	F↔S
COTTON	Spot	0.9955* (404.25)	-3.9784* (-20.63)	0.4914* (15.64)	0.1322* (5.774)	- 0.0302** (-2.617)	0.1924 [0.6610]	
	Futures	-0.0029 (-0.189)	-1.4732* (-13.45)	0.8499* (66.54)	0.0132 (1.217)	- 0.0149** (-2.099)	0.4293 [0.5125]	F→S
CRUDE PALM OIL	Spot	0.0569* (3.778)	-1.0100* (-7.035)	0.8893* (54.44)	0.2796* (12.33)	- 0.0196** (-1.995)	0.1824 [0.6694]	F↔S
	Futures	0.0850* (5.429)	-2.1386* (-12.88)	0.7659* (36.27)	0.361* (14.59)	-0.0103* (-2.675)	0.2890 [0.5910]	
GAUR GUM	Spot	0.0522* (2.797)	-0.8643* (-7.907)	0.9054* (65.87)	0.2240* (10.99)	-0.030** (-2.491)	0.3190 [0.8653]	
	Futures	0.0449** (2.123)	-0.5151* (-5.069)	0.9484* (76.01)	0.1781* (8.136)	-0.032** (-2.521)	1.1230 [0.3389]	F↔S
GAUR SEED	Spot	0.0220 (1.156)	-1.2449* (-6.826)	0.8437* (36.58)	0.2645* (10.17)	- 0.0199** (-1.964)	0.0786 [0.7793]	
	Futures	0.0335 (1.486)	-3.0090* (-13.43)	0.6810* (18.87)	0.3025* (11.96)	-0.0120* (-2.660)	0.1141 [0.7356]	F↔S
GAUR	Spot	0.0735* (5.139)	-1.0753* (-11.64)	0.9085* (34.91)	0.2985* (17.35)	-0.0445* (-3.655)	1.3543 [0.2133]	F→S
	Futures	0.0233	-0.4297*	0.9576*	0.0862	-0.0448*	0.4342	

		(1.176)	(-3.567)	(28.92)	(1.232)	(-2.851)	[0.5101]	
JEERA	Spot	0.0087 (0.781)	-0.6533* (-6.801)	0.9297* (29.36)	-0.026** (-2.488)	-0.028** (-2.488)	0.1955 [0.8994]	F→S
	Futures	0.0681* (3.892)	-0.3531* (-7.904)	0.9709* (24.93)	0.0021 (1.507)	-0.0617* (-9.189)	0.9862 [0.3210]	
KAPAS	Spot	0.0328 (1.633)	-0.9465* (-6.553)	0.8979* (50.91)	0.2333* (10.65)	- 0.0215** (-2.402)	2.1221 [0.1456]	F→S
	Futures	-0.0143 (-0.9142)	-0.4613* (-9.0538)	0.9554* (146.09)	0.0305 (1.306)	- 0.0020** (-2.2164)	1.6785 [0.136]	
MAIZE	Spot	0.0106 (0.6824)	-0.3772* (-12.378)	0.9651* (48.04)	0.1840* (14.278)	-0.0313* (-3.8294)	1.4984 [0.107]	F→S
	Futures	0.0231 (1.5052)	-0.5392* (-8.9472)	0.9436* (32.05)	0.0155 (1.490)	- 0.0021** (-2.1928)	1.5796 [0.1623]	
MENTA OIL	Spot	0.0671* (2.9498)	-3.8939* (-8.3680)	0.5188* (8.7673)	0.2709* (8.9989)	-0.0949* (5.1441)	0.0013 [0.9708]	F→S
	Futures	0.0625* (3.9887)	-1.9057* (-12.314)	0.7879* (36.377)	0.0614 (1.080)	-0.2343* (11.137)	0.0788 [0.9954]	
MUSTARD OIL	Spot	0.1407* (7.5457)	-0.7275* (-15.039)	0.9445* (26.812)	0.4124* (9.1984)	-0.0449* (-3.0510)	0.0121 [0.9124]	F→S
	Futures	0.0423** (2.4085)	-0.2814* (-17.261)	0.9772* (51.86)	0.0761 (1.584)	-0.0307* (-5.5804)	0.8504 [0.5138]	
PEAS	Spot	0.0312 (1.6921)	-0.2434* (-9.5480)	0.9748* (48.26)	0.0943* (12.436)	-0.0538* (-6.3748)	0.1357 [0.7125]	F↔S
	Futures	0.0364** (2.0674)	-1.5233* (-15.466)	0.8286* (34.858)	0.4253* (21.298)	-0.0343* (-2.742)	0.2541 [0.6142]	
	Spot	0.0598*	-0.3742*	0.9654*	0.1582 * (10.292)	-0.0251*	1.2870	F→S

PEPPER		(3.7889)	(-8.1060)	(38.90)		(-2.8031)	[0.2567]	
	Futures	0.035**	-5.444*	0.095**	0.0081	-0.204*	0.0134	
		(1.973)	(-19.24)	(1.972)	(1.586)	(-8.031)	[0.9077]	
POTATO	Spot	-0.005	-0.049*	0.992*	0.098	-0.122*	0.0029	
		(-0.368)	(-11.36)	(14.3)	(1.285)	(-44.35)	[0.9568]	
	Futures	0.093*	-0.656*	0.915*	0.241*	-0.103*	0.8521	S→F
		(4.071)	(-14.03)	(13.68)	(6.680)	(-10.11)	[0.3560]	
RUBBER	Spot	-0.100*	-3.791*	0.474*	0.013	-0.481*	0.0215	
		(-4.768)	(-29.75)	(22.28)	(0.741)	(-20.26)	[0.8834]	
	Futures	0.064*	-1.070*	0.871*	0.327*	-0.053*	1.4360	S→F
		(4.059)	(-14.94)	(89.21)	(4.128)	(-5.619)	[0.2193]	
SOYA BEAN	Spot	0.0668*	-2.839*	0.666*	0.165	-0.172*	0.0175	
		(4.184)	(-17.71)	(30.49)	(1.641)	(-13.40)	[0.8945]	
	Futures	0.011**	-0.323*	0.971*	0.837*	-0.004**	4.6910	S→F
		(2.032)	(-16.13)	(371.4)	(6.78)	(-2.571)	[0.2387]	
SOYA OIL	Spot	0.052*	-2.474*	0.833*	0.640**	0.167*	0.3827	
		(3.280)	(-18.81)	(43.21)	(2.431)	(9.648)	[0.5361]	
	Futures	0.062*	-0.175*	0.987*	0.122	-0.012**	0.2771	F→S
		(4.232)	(-9.966)	(500.3)	(1.391)	(-1.977)	[0.8419]	
SUGAR	Spot	0.063*	-0.601*	0.952*	0.385*	-0.059*	0.2747	
		(4.014)	(-21.07)	(45.5)	(54.75)	(-6.186)	[0.6001]	
	Futures	0.091*	-0.314*	0.974*	0.196*	-0.008**	2.3449	F↔S
		(7.005)	(-14.27)	(61.1)	(21.06)	(-1.982)	[0.1257]	
TURMERIC	Spot	0.069*	-4.249*	0.439*	0.184*	-0.028**	0.0050	
		(4.555)	(-6.483)	(4.973)	(7.010)	(-1.994)	[0.9434]	
	Futures	-0.056*	-4.838*	0.467*	0.910*	-0.104*	0.2362	
		(-7.868)	(-31.19)	(24.18)	(81.78)	(-8.425)	[0.6269]	F↔S
	Spot	0.117*	-0.590*	0.947*	0.345*	-0.079*	0.0032	F→S

WHEAT		(6.685)	(-15.39)	(16.88)	(3.306)	(-8.629)	[0.9548]	
	Futures	0.293*	-7.789*	0.011	0.053	-0.316*	0.0059	
		(19.30)	(-148.86)	(1.457)	(1.240)	(-12.15)	[0.9387]	
BULLION								
GOLD	Spot	-0.001	-5.967*	0.011	-0.252	-0.028**	0.0005	
		(-0.512)	(-8.589)	(0.104)	(-6.413)	(-1.986)	[0.9809]	
	Futures	0.019**	-6.216*	0.053	-0.028*	-0.123*	0.0048	F→S
		(1.991)	(-4.059)	(0.234)	(-1.613)	(-4.614)	[0.9443]	
PLATINUM	Spot	0.041**	-8.080*	-0.198*	0.024	-0.118*	0.0077	
		(1.980)	(-17.61)	(-2.905)	(1.015)	(-5.136)	[0.9298]	
	Futures	0.026	-0.896*	0.907*	0.274*	-0.027**	1.8649	S→F
		(1.474)	(-12.20)	(14.20)	(5.482)	(-2.411)	[0.1138]	
SILVER	Spot	-0.048**	-0.084*	0.978*	0.145*	-0.038*	0.3176	
		(-1.968)	(-8.452)	(19.80)	(12.45)	(-4.309)	[0.5730]	
	Futures	0.084*	-1.974*	0.866*	0.609*	-0.192*	0.1141	F↔S
		(3.509)	(-17.73)	(12.08)	(20.20)	(-11.17)	[0.7355]	
ENERGY								
ATF	Spot	0.028**	-5.414*	0.307*	0.656*	-0.138*	0.0114	
		(2.112)	(-20.19)	(8.374)	(8.802)	(-6.472)	[0.9149]	
	Futures	0.017**	-0.524*	0.941*	0.021	-0.063*	1.5915	F→S
		(2.120)	(-9.419)	(11.94)	(1.275)	(-7.233)	[0.1592]	
BRENT CRUDE OIL	Spot	-0.117*	-7.826*	-0.059*	0.905*	-0.215*	0.0584	
		(-8.681)	(-136.26)	(-6.224)	(10.06)	(-9.436)	[0.8090]	
	Futures	0.214*	-5.854*	0.290*	0.121	-0.521*	0.0391	F→S
		(12.18)	(-33.98)	(12.95)	(1.639)	(-34.28)	[0.8431]	
CRUDE OIL	Spot	0.0451*	-1.0294*	0.8687*	0.083	-0.0092	0.4083	
		(2.6005)	(-9.188)	(55.882)	(1.179)	(-0.6239)	[0.5228]	S→F
	Futures	-0.0047	-1.1366*	0.8164*	-0.418**	-0.1261*	0.0136	

		(-0.9336)	(-6.2155)	(27.477)	(-3.5264)	(-9.455)	[0.9993]	
FURNACE OIL	Spot	0.0154 (1.0647)	-0.5739* (-10.316)	0.9429* (12.36)	0.1475* (18.222)	-0.0035** (-2.4607)	1.0288 [0.3988]	F→S
	Futures	0.0103 (0.7254)	-0.4871* (-11.121)	0.9552* (18.24)	0.0230 (1.616)	-0.0366* (-3.8231)	1.5890 [0.2075]	
GASOLINE	Spot	0.0337** (2.3986)	-0.4418* (-8.8585)	0.9600* (15.09)	0.2156* (3.458)	-0.0202* (-2.8977)	1.7736 [0.1313]	
	Futures	0.0520** (2.2905)	-1.722* (-9.4187)	0.6642* (17.913)	0.0398 (0.552)	-0.0396** (-1.9706)	0.0133 [0.9999]	F→S
HEATING OIL	Spot	0.0487** (2.2277)	-0.4907* (-8.1087)	0.9495* (31.51)	0.1643* (11.761)	-0.0540* (-4.9461)	0.0124 [0.9949]	
	Futures	0.0007 (0.0545)	-0.1229* (-5.9842)	0.9924* (40.72)	0.0887 (1.783)	-0.04981* (-7.6069)	0.0348 [0.8520]	F→S
NATURAL GAS	Spot	0.0408* (2.6526)	-0.5202* (-10.197)	0.9475* (41.23)	0.2192* (15.073)	-0.0252* (-2.9337)	1.2330 [0.1965]	
	Futures	0.0364** (2.2973)	-0.9159* (-9.2724)	0.8921* (57.522)	0.2469* (12.474)	-0.02315** (-1.9763)	0.4351 [0.8242]	F↔S
METAL								
ALUMINIUM	Spot	-0.01362 (-0.9080)	-0.3735* (-7.2996)	0.9620* (50.34)	0.1463* (10.460)	-0.0026** (-2.3199)	0.9520 [0.3292]	
	Futures	0.0301 (1.5911)	-2.4621* (-13.072)	0.8653* (26.836)	0.3990* (14.377)	-0.0171** (-1.9650)	0.4491 [0.8141]	F↔S
COPPER	Spot	-0.058** (-1.978)	-0.094* (-7.452)	0.988* (39.80)	0.1753** (2.451)	-0.048* (-3.309)	0.2176 [0.4730]	F→S

	Futures	0.084* (3.509)	-1.974* (-17.73)	0.866* (52.08)	0.0609 (1.120)	-0.192* (-11.17)	0.1141 [0.7355]	
IRON ORE	Spot	0.018** (2.112)	-6.514* (-18.19)	0.207* (7.374)	0.0556 (1.560)	-0.148* (-7.472)	0.0114 [0.9249]	
	Futures	0.018** (2.170)	-0.534* (-8.419)	0.951* (12.94)	0.2237* (4.257)	-0.053* (-6.233)	1.6015 [0.1692]	S→F
LEAD	Spot	-0.127* (-7.681)	-9.826* (-36.26)	-0.060* (-4.224)	1.405* (40.06)	-0.215* (-8.436)	0.0584 [0.7090]	
	Futures	0.194* (11.18)	-4.854* (-30.98)	0.301* (11.95)	1.031* (22.09)	-0.421* (-24.28)	0.0291 [0.9431]	F↔S
NICKLE	Spot	0.0451* (2.5105)	-1.0294* (-8.188)	0.8687* (15.882)	0.2083* (8.5179)	-0.0092 (-0.5239)	0.4083 [0.6228]	
	Futures	-0.0047 (-0.9636)	-1.1366* (-6.2355)	0.8164* (17.487)	-0.0418* (-3.5764)	-0.1261* (-9.2455)	0.0136 [0.8593]	F↔S
SPONGE IRON	Spot	0.0154 (1.0647)	-0.5839* (-10.316)	0.9329* (132.36)	0.1375 (1.222)	-0.0136 (-0.4607)	0.0288 [0.3988]	
	Futures	0.0203 (0.4254)	-0.4871* (-10.121)	0.8552* (19.24)	0.4230* (4.616)	-0.0366* (-4.8831)	0.5890 [0.2075]	S→F
STEEL FLAT	Spot	0.0237** (2.3986)	-0.5418* (-7.8585)	0.8610* (15.09)	0.2156* (13.458)	-0.0202* (-2.8977)	0.7736 [0.1313]	
	Futures	0.0510** (2.1905)	-1.722* (-8.4187)	0.5642* (16.913)	0.4398* (10.952)	-0.0396** (-1.9706)	0.0134 [0.9924]	F↔S
THERMAL COAL	Spot	0.0587** (2.3277)	-0.4007* (-7.1087)	0.9695* (13.51)	0.3743** (1.981)	-0.0541* (-5.9461)	0.0124 [0.9349]	
	Futures	0.0005 (0.0445)	-0.1219* (-4.9842)	0.9424* (12.72)	0.0987 (1.583)	-0.04981* (-7.6069)	0.0348 [0.8520]	F→S
	Spot	0.0408*	-0.4202*	0.9475*	0.0192	-0.0252*	1.2330	S→F

TIN		(2.6526)	(-10.797)	(14.23)	(1.073)	(-2.9337)	[0.1965]	
	Futures	0.0364 (0.2973)	-0.9459* (-9.3724)	0.8921* (17.522)	0.2469* (4.484)	- 0.02315* (-2.8363)	0.4351 [0.8242]	
ZINC	Spot	-0.01362 (-0.9080)	-0.3735* (-7.2996)	0.9620* (15.34)	0.1463* (10.560)	- 0.0126** (-2.3199)	0.9520 [0.3292]	F↔S
	Futures	0.0301 (1.5911)	-2.4621* (-13.072)	0.8753* (17.836)	0.3790* (15.377)	-0.0371* (-2.9750)	0.9198 [0.8141]	

Notes: Figures in ( ) parentheses are z-statistics. * (**) denote the significance at the one and five per cent level, respectively. Figures in [ ] indicates the probability value of ARCH LM test. ARCH-LM is the Lagrange Multiplier test for ARCH effects (Engle, 1982).

The Bivariate EGARCH model is used to obtain estimate that are used to verify the presence of volatility spillover systems that caused futures and spot prices in the commodities representing Bullion, Agriculture, Energy and Metal. The observed facts uncover the GARCH outcomes across selected commodities and confirm that the outcomes are significant statistically, thereby indicating the presence of persistence degree of volatility with respect to both spot as well as futures market returns of the selected commodities which belong to Bullion, Agriculture, Energy and Metal. The above outcomes indicate that after a surprise occurrence happens in the futures and spot markets for a particular commodity its effects persists in the market for a considerable period of time.

The leverage effects are statistically significant for both futures and spot market returns of respective commodities that belong to Agriculture, Bullion, Energy and Metal, specifying the presence of leverage causes. It also becomes obvious that negative shock effects of conditional volatility impact much more significantly as compared to positive shock effects of an identical magnitude with reference to commodities that belongs to Bullion, Agriculture, Energy and Metal, respectively. This implies that negative shock effects create much greater levels of volatility when compared to positive shocks of identical magnitude.

Most importantly, the Bivariate EGARCH results demonstrate varied substantiation of spillover consequences. The factual data reveals that for agricultural commodities spillover effects can be mapped to be taking place from futures price market to spot market, this holds true for commodities namely CHANNA, CHILLI, KAPAS, MENTA OIL, WHEAT, MUSTARD OIL, MAIZE, SOYA OIL, PEPPER, CASTOR SEEDS, JEERA, COTTON and BARLEY. This implies that information spillover to some extent occurs from futures market to the spot market. The futures market further possesses the capability to reveal a good quantum of fresh information via the medium of novel innovation

The tabulated data corroborates the presence of bidirectional spillover outcomes linking futures prices and spot price market for COTTON SEED OIL CAKE, CORRIANDER, GAUR SEED, GAUR GUM, SUGAR, TURMERIC, PEAS and CRUDE PALM OIL. This further confirms that spot market prices as well as future market prices for the eight commodities possess the ability to reveal large quantum of latest market information through the medium of novel innovation.

The Bivariate EGARCH model states that the spillover effect occurs from spot market prices to futures prices and this can be confirmed for agricultural commodities with regard to SOYA BEAN, RUBBER and POTATO. This effect indicates the occurrence of information spillover. Besides the spot market price of SOYA BEAN, RUBBER and POTATO has the means to reveal large quantum of latest information.

The results of Bivariate EGARCH model for Bullion show that unidirectional spillover exists from futures to spot market prices and spot to futures market price in the case of GOLD and PLATINUM, respectively. For SILVER, bidirectional spillover exists between futures and spot market prices.

As far as the Energy commodities are concerned, the Bivariate EGARCH model reports that there is presence of unidirectional spillover effect moving from futures to spot market with regard to ATF, BRENT CRUDE OIL, GASOLINE, HEATING OIL and FURNACE OIL and bilateral spillover effects exist between futures and spot market prices for NATURAL GAS. One-way spillover effect takes place from spot to futures market price for CRUDE OIL.

In the case of Metal commodities, the Bivariate EGARCH model depicts that the bidirectional spillover exists between spot and futures markets in the case of five Metal commodities, viz. ALUMINIUM, NICKEL, LEAD, STEEL FLAT and ZINC. The analysis

also confirms the unidirectional spillover from spot market price to futures market price and futures market price to spot market price in the case of IRON ORE, SPONGE IRON and TIN and COPPER and THERMAL COAL, respectively.

On the whole, from the study results, it is clear that the unilateral spillover runs from futures market price to spot market price in majority of the underlying commodities that belong to Agriculture and Energy sector. And Bullions show mixed evidence. Following this, the feedback spillover effect exists between spot and futures market prices in majority of the underlying commodities that belongs to Metals.

The variation of spillover effect from one commodity to another is due to the fact that the selected underlying commodities from different industry groups are widely dispersed in terms of its industry-specific activities and also they are subject towards prevailing differential market frictions such as transaction costs, initial margin requirements, leverage positions and flexibility of short positions and liquidity differences between spot and futures markets. Besides, the present study suggests that depending on the relative proportion of informed to uninformed (noise) traders migrating from the spot market to the futures market, the spillover effect between futures and spot market of selected underlying commodities of respective industry groups may differ.

To verify the sturdiness of estimates obtained through Bivariate EGARCH outcomes with respect to commodities that belong to Bullion, Agriculture, Energy and Metal, the ARCH-LM (Engle, 1982) test outcomes imply the reasonableness and correctness of the Bivariate EGARCH model to emphasise the time varying volatility (ARCH) impacts in the scrutinised time series for stocks belonging to Bullion, Agriculture, Energy and Metal.

CHAPTER 7

LINKAGES AND VOLATILITY SPILLOVER AMONG MCX COMMODITY MARKETS AND NSE NIFTY MARKET

7.1 Introduction:

This chapter investigates the linkages and volatility spillover among the MCX commodity markets and NSE NIFTY market. The commodity markets considered for the study are MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and the equity market considered is NSE NIFTY market.

It evaluates whether there is unidirectional flow of information from the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the NSE NIFTY equity market, or NSE NIFTY equity market to the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL market or a bidirectional flow of information between these markets. The results help to identify the extent of linkages between the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the NSE NIFTY equity market and the speed of adjustments between the markets. Further, the study evaluates whether the volatility spills over from the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the NSE NIFTY equity market or NSE NIFTY market to the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL market or a bidirectional flow of volatility between the two markets.

7.2 Descriptive Statistics:

Table- 7.1 Descriptive Statistics of MCX Commodity Markets Return and NSE NIFTY Market Return

Statistics	MCXAGRI	MCXCOMDEX	MCXENERGY	MCXMETAL	NSE NIFTY
Mean	0.0003	0.0002	0.0000477	0.0004	0.0005
Std. Dev.	0.0082	0.0127	0.0283	0.0126	0.0158
Skewness	-1.5675	-0.0582	0.0646	-0.9244	-0.0094
Kurtosis	169.73	37.654	238.69	13.322	11.845
Jarque-Bera Statistics	2782326* (0.000)	120144* (0.000)	5557564* (0.000)	11001* (0.000)	7827* (0.000)
Observations	2401	2401	2401	2401	2401

Notes: * – indicates significance at one per cent level. Probability Values are in Parenthesis.

Table 7.1 depicts the descriptive statistics of the MCX commodity markets return and NSE NIFTY market return. The average closing prices of the MCXMETAL and MCXAGRI are higher than the MCXCOMDEX and MCXENERGY markets. On the other hand, the average returns of NSE-NIFTY are more than the averages return of MCX commodity markets during the study period. All commodity markets and equity market reflecting the standard deviation ranges between 0.0082 and 0.0158.

7.3 Unit Root Test:

Table- 7.2 Results of Unit Root Test

Name of Market	Levels	First Difference
Augmented Dickey-Fuller		
MCXAGRI	-2.0466	-46.386*
MCXCOMDEX	-1.5327	-44.277*
MCXENERGY	-2.0729	-51.644*
MCXMETAL	-2.2645	-62.688*
NSE-NIFTY	-2.0466	-46.386*
Philips-Perron Test		
MCXAGRI	-2.0623	-46.356*
MCXCOMDEX	-1.5208	-44.929*
MCXENERGY	-2.0722	-51.589*
MCXMETAL	-2.2331	-63.785*
NSE-NIFTY	-2.0623	-46.356*

Notes: * – indicates significance at one per cent level. Optimal lag lengt determined by the Schwarz Information Criterion (SIC) for the Augme Dickey-Fuller Test and Philips-Perron Test.

Table 7.2 shows the results of ADF and PP unit root test. The ADF and PP test statistics are shown for the log price series and the return series for indices of commodity markets viz. MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. NSE-NIFTY market. Based on Schwarz information criteria, the optimal lag length is chosen for ADF and PP tests.

The ADF and PP test statistics indicate that the log price series and the return series for indices of commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and equity market, viz. NSE-NIFTY market contain unit root, implying the fact that both the commodity and equity prices series of MCX commodity markets and NSE- NIFTY are non-stationary, respectively. The ADF and PP test statistics reject the hypothesis of a unit root in return series, implying the fact that the return series are stationary.

7.4 Johensen Cointegration Test:

Once the MCX commodity markets and NSE-NIFTY market price series of each commodity are integrated at same order, the Johensen Julius test of Cointegration is employed to confirm the presence of extended term linkage involving MCX commodity markets viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively and NSE-NIFTY equity market.

The Johansen Cointegration test is sensitive to the selection of optimal lag length and the necessary lag length of commodity and equity price series for the respective indices is determined by the Schwarz Information Criterion (SIC) and it reveals optimal lag of two for MCXAGRI and NSE-NIFTY, MCXENERGY and NSE-NIFTY, and MCXMETAL

and NSE-NIFTY and one for MCXCOMDEX and NSE-NIFTY. **(Refer Annexure 3-Results of VAR Lag Length Selection)**

Johansen's cointegration test was performed to examine the long-run relationship between the MCX commodity markets and NSE-NIFTY equity market and its results are presented in Table - 7.3.

Table- 7.3 Results of Johansen Cointegration Test

Name of the Markets	vector (r)	Trace test Statistics (λ_{trace})	Maximal Eigen value (λ_{max})	5 % Critical value for Trace Statistics	5 % Critical value for Max-Eigen Statistics	Remarks
MCXAGRI & NIFTY	H_0: r = 0	18.966**	16.805**	17.261	15.892	*Cointegrated*
	H_1: r ≥ 1	2.1605	2.1605	9.1645	9.1645	
MCXCOMDEX & NIFTY	H_0: r = 0	19.313**	15.835**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	3.4777	3.4777	3.8414	3.8414	
MCXENERGY & NIFTY	H_0: r = 0	19.790**	17.706**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	2.0840	2.0840	3.8414	3.8414	
MCXMETAL & NIFTY	H_0: r = 0	18.848**	16.629**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	4.2188	4.2188	4.8414	4.8414	

Notes: ** – indicates significance at five per cent level. The significant of the statistics is based on 5 per cent critica values obtained from Johansen and Juselius (1990). r is the number of cointegrating vectors. H_0 represents the null hypothesis of presence of no cointegrating vector and H_1 represents the alternative hypothesis of presence of cointegrating vector.

The results of Johansen's maximum eigen (λ_{max}) and trace statistics (λ_{trace}) indicate the presence of one cointegrating vector between the MCX commodity markets viz. MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and NSE-NIFTY equity market prices at 5% level respectively.

The outcomes indicate the existence of at least one cointegration equation among MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and NSE-NIFTY equity market prices, respectively. The null hypothesis of no cointegration is rejected which reveals that one cointegration relationship exists between MCX commodity markets and NSE NIFTY equity prices. The empirical results found that there exists long-term

equilibrium relationship between MCX commodity markets and NSE NIFTY equity prices in the case of all the selected indices. Thus, the selected MCX commodity markets and NSE-NIFTY equity prices share common long-run information.

7.5 Vector Error Correction Model (VECM):

The VECM results are reported in Table 7.4. It shows the short-run and long-run dynamics between the two markets. The lag length of the series is selected for Vector Error Correction Model (VECM) on the basis of Schwarz Information Criteria (SIC). The dynamic VECM representation provides us with a framework to test for the causal dynamics in the Granger sense among the price series through both short-run and error-correction channels (ECTs) of causation. Short-run market causality test will determine whether MCX commodity markets price in different markets respond instantaneously to changes in NSE-NIFTY prices. The coefficient of the lagged error correction term (ECTs) shows the portion by which the long-run disequilibrium in the dependant variable is being corrected in each short period to have stable long-run relationship. If both short-run causality coefficient and ECTs are insignificant, the market can be treated as exogenous to the system (Masih and Masih 1997).

The table result shows that coefficient of error correction term (ECT) in the NSE-NIFTY equation is statistically significant; while the coefficients of the ECT in the MCXAGRI equation is found to be statistically insignificant, suggesting a unidirectional error correction. The VECM result shows a unidirectional error correction. This indicates that the MCXAGRI commodity price leads the NSE-NIFTY price in the long-run.

For MCXMETAL and MCXCOMDEX, the Error Correction coefficients (ECT) in the MCX commodity equations are statistically significant; while the coefficients of the ECTs

in the NSE-NIFTY spot equations are found to be statistically insignificant, suggesting a unidirectional error correction. This indicates that the NSE-NIFTY price leads the MCXMETAL and MCXCOMDEX commodity prices in the long-run.

For MCXENERGY, the Error Correction coefficient (ECT) in the MCX commodity equation, and also the coefficient of the ECT in the NSE-NIFTY equation are statistically significant, suggesting a bidirectional relationship between the MCXENERGY and NSE-NIFTY market prices in the long-run.

Furthermore, the empirical evidence indicates that the lagged coefficient of changes in MCXAGRI prices in NSE-NIFTY equation is found to be statistically significant, whereas, the lagged coefficients of changes in NSE-NIFTY prices in MCXAGRI equations are found to be statistically insignificant, implying that unidirectional causation runs from MCXAGRI prices to NSE-NIFTY prices in the short-run.

For MCXMETAL and MCXCOMDEX, the lagged coefficient of changes in MCX commodity markets prices in NSE-NIFTY equations are found to be statistically significant, as well as the lagged coefficients of changes in NSE-NIFTY prices in MCX commodity markets price equations are found to be statistically significant, implying that bidirectional causation exists among MCXMETAL prices and NSE-NIFTY prices, and MCXCOMDEX prices and NSE-NIFTY prices in the short-run.

In addition, the empirical evidence indicates that the lagged coefficient of changes in NSE-NIFTY prices in MCXENERGY equation is found to be statistically significant, whereas, the lagged coefficients of changes in MCXENERGY prices in NSE-NIFTY equation is

found to be statistically insignificant, implying that unidirectional causation runs from NSE-NIFTY prices to MCXENERGY prices in the short-run.

By and large, the evidences from VECM estimates show mixed evidence. The MCXAGRI commodity price leads the NSE-NIFTY price in the long-run. NSE-NIFTY price leads the MCXMETAL and MCXCOMDEX commodity prices in the long-run. Besides, bidirectional relationship between the MCXENERGY and NSE-NIFTY market prices in the long-run.

Unidirectional causation runs from MCXAGRI prices to NSE-NIFTY prices in the short-run. Bidirectional causation exists among MCXMETAL prices and NSE-NIFTY prices, and MCXCOMDEX prices and NSE-NIFTY prices in the short-run. And unidirectional causation runs from NSE-NIFTY prices to MCXENERGY prices in the short-run.

Table- 7.4 Results of Vector Error Correction Model for MCX Commodity Markets and NSE-NIFTY Market

	MCXAGRI & NIFTY		MCXCOMDEX & NIFT		MCXENERGY & NIFTY		MCXMETAL & NIFT	
	ΔN_t	ΔC_t	ΔN_t	ΔC_t	ΔN_t	ΔC_t	ΔN_t	ΔC_t
ECT	-0.0046*	-0.0013	0.0002	0.0003**	-0.0001*	-0.0003**	0.0005	0.0012**
	(0.0015)	(0.0008)	(0.0002)	(0.0001)	(8.9E-05)	(0.0001)	(0.0006)	(0.0005)
	[-2.9379]	[-1.5938]	[1.4427]	[2.1152]	[-2.1285]	[-2.0154]	[0.9352]	[2.4968]
ΔN_{t-1}	0.0575*	0.0089	0.0585*	0.0647*	0.0555*	0.0764**	0.0632*	0.0928*
	(0.0204)	(0.0106)	(0.0206)	(0.0159)	(0.0205)	(0.0356)	(0.0206)	(0.0163)
	[2.8166]	[0.8439]	[2.8435]	[4.0552]	[2.6994]	[2.1446]	[3.0662]	[5.6777]
ΔN_{t-2}	-0.0153	-0.0028			-0.0148	0.0119	-0.0142	0.0003
	(0.0204)	(0.0106)			(0.0205)	(0.0357)	(0.0207)	(0.0164)
	[-0.7493]	[-0.2627]	---	---	[-0.7223]	[0.3348]	[-0.6889]	[0.0210]
ΔC_{t-1}	-0.0555***	0.0962*	-0.0489***	-0.0647*	-0.0090	-0.2580*	-0.0729*	-0.0458**
	(0.0292)	(0.0204)	(0.0264)	(0.0205)	(0.0118)	(0.0205)	(0.0259)	(0.0205)
	[-1.6672]	[4.7001]	[-1.8514]	[-3.1563]	[-0.7641]	[-12.540]	[-2.8135]	[-2.2298]
ΔC_{t-2}	0.0262	0.0162			-0.0121	-0.0529*	0.0299	-0.0231
	(0.0392)	(0.0204)			(0.0118)	(0.0205)	(0.0258)	(0.0205)
	[0.6703]	[0.7941]	---	---	[-1.0209]	[-2.5753]	[1.1596]	[-1.1288]
C	0.0005***	0.0003***	0.0005***	0.0002	0.0005***	2.30E-05	0.0005***	0.0004
	(0.0003)	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0005)	(0.0003)	(0.0002)
	[1.7532]	[1.9022]	[1.7289]	[1.0346]	[1.7281]	[0.0409]	[1.7667]	[1.5868]

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SIC). N_t and C_t are the NSE-NIFTY and MCX-Commodity markets price respectively, *, ** and *** denote the significance at the one, five and ten per cent leve respectively. [ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

II. Volatility Spillover

7.6 ARCH-LM Test:

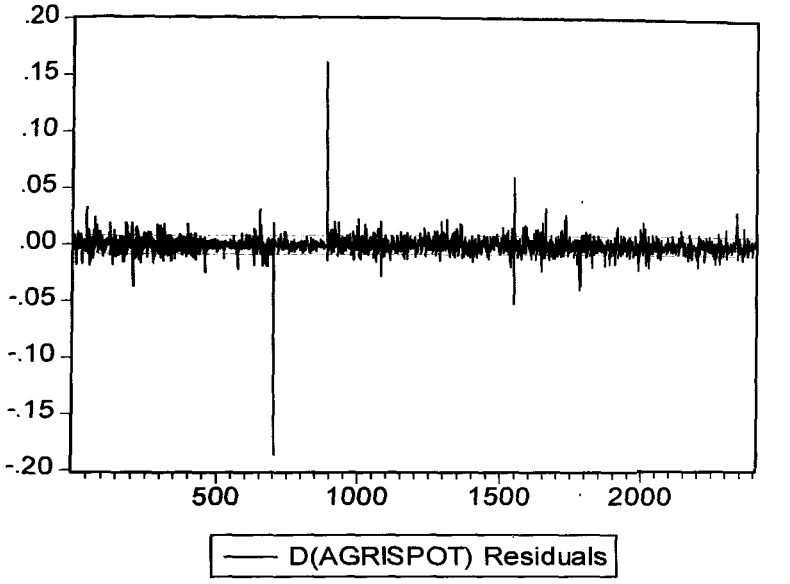
Furthermore, the Engle (1982) ARCH-LM test statistics was conducted in order to test the null hypothesis of no ARCH effects on the commodity markets returns of MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. NSE-NIFTY market and its results are reported in the Table - 7.5.

Table- 7.5 ARCH LM Test Results of MCX Commodity Markets Return and NSE NIFTY Market Return

Name of the Commodity	ARCH LM Statistics	
	Spot Returns	Prob. Value
MCXAGRI	45.324	0.000
MCXCOMDEX	630.67	0.000
MCXENERGY	664.65	0.000
MCXMETAL	99.636	0.000
NSE-NIFTY	45.843	0.000

The test statistics are highly significant at one percent levels, confirming the existence of significant ARCH effects on the commodity markets returns of MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. NSE-NIFTY market.

Figure 7.1: Volatility Clustering of Commodity Market Returns of MCXAGRI and NSE-NIFTY Return



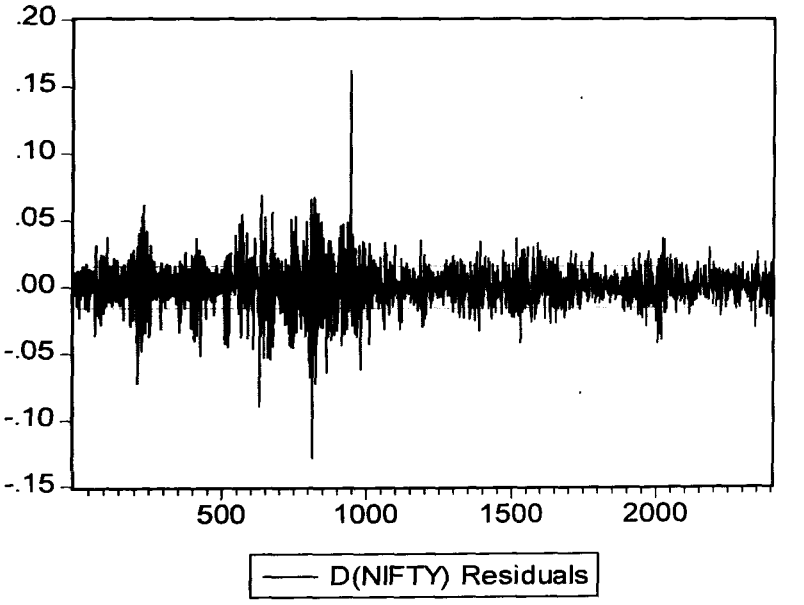
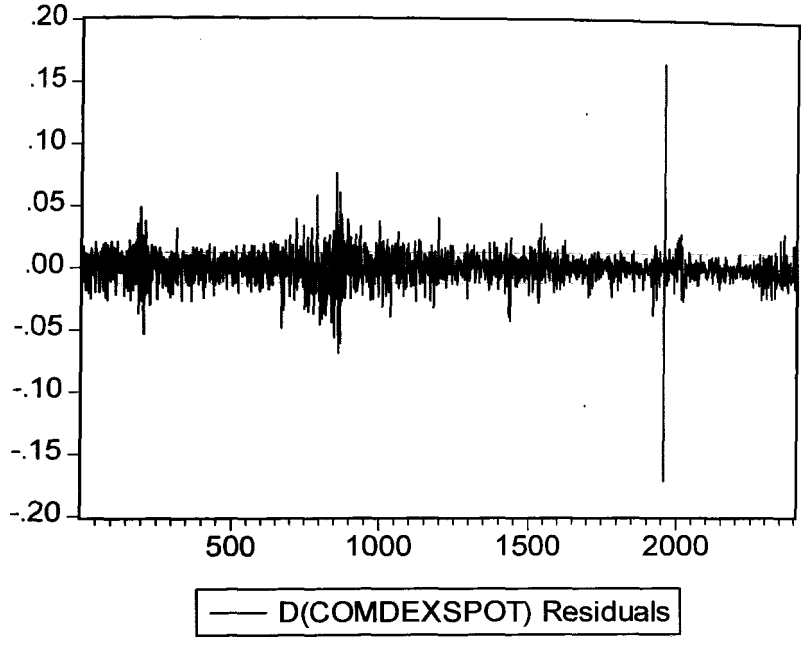


Figure 7.2: Volatility Clustering of Commodity Market Returns of MCXCOMDEX and NSE-NIFTY Return



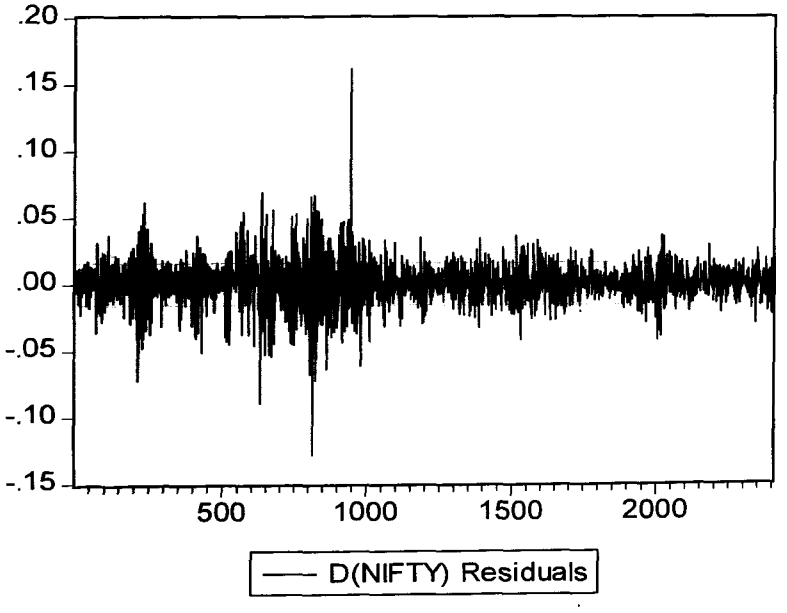
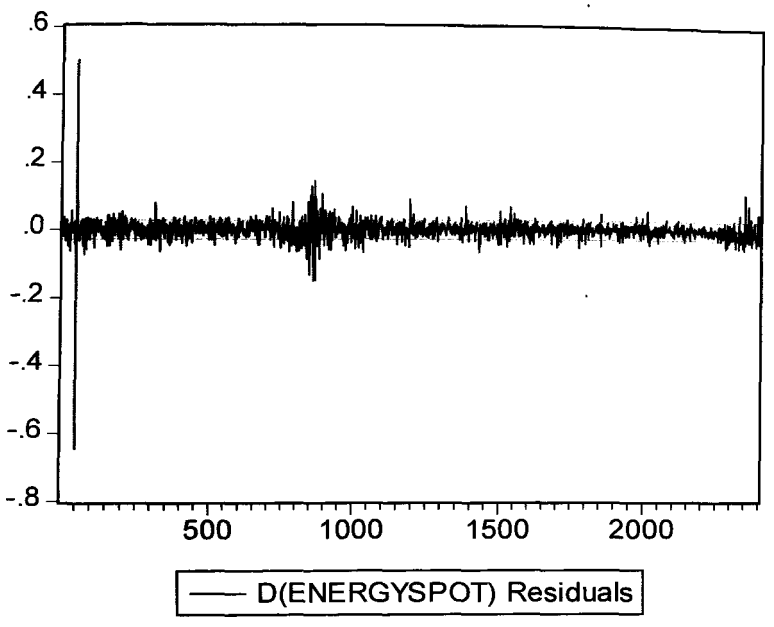


Figure 7.3: Volatility Clustering of Commodity Market Returns of MCXENERGY and NSE-NIFTY Return



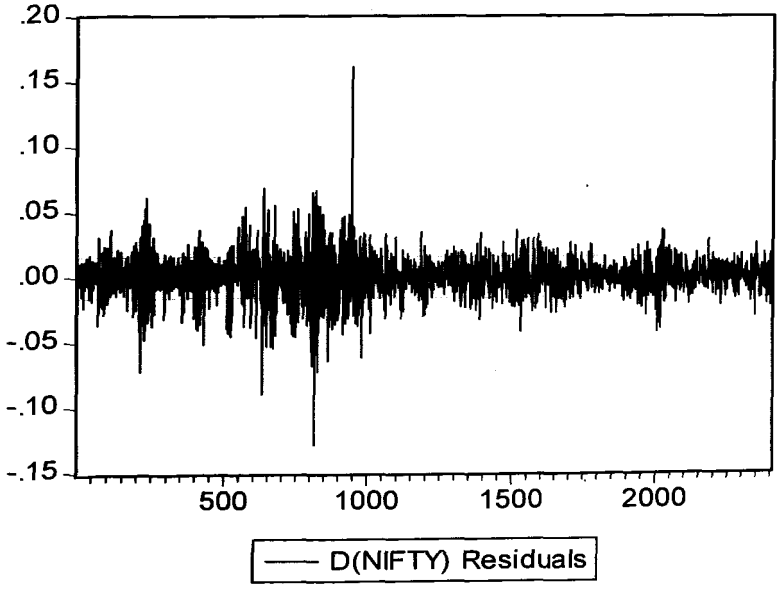
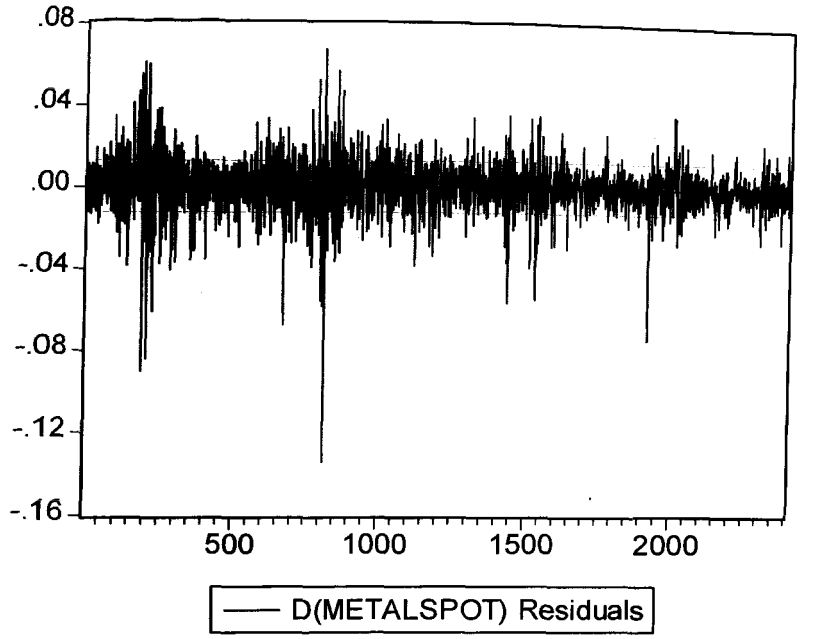
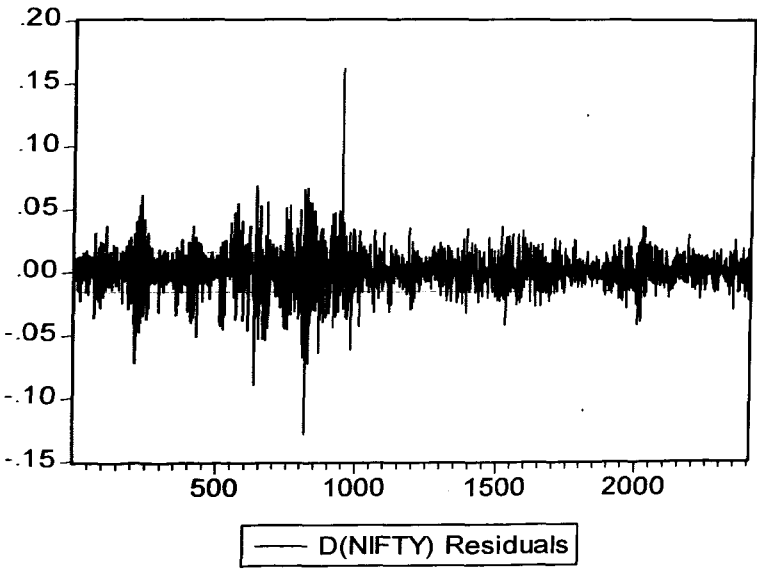


Figure 7.4: Volatility Clustering of Commodity Market Returns of MCXMETAL and NSE-NIFTY Return





Besides, Figure 7.1 to 7.4 shows the volatility clustering of NSE-NIFTY and MCX commodity markets returns, namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. The graphical representation of the residuals obtained from the NIFTY and MCX commodity markets returns exhibits significant ARCH effects i.e. volatility clustering and suggest that Bivariate EGARCH model adequately maps the heteroscedastic

impact and volatility clustering to enable modeling of the return volatility of NSE-NIFTY and MCX commodity markets.

7.7 Bivariate EGARCH Model:

The table 7.6 shows the estimates of Bivariate EGARCH model to determine the volatility spillover mechanism taking place between MCX Commodity Markets Return and NSE-NIFTY Market Return.

Table- 7.6 Results of Volatility Spillover for the MCX Commodity Markets Return and NSE- NIFTY Market Return

Paramet	AGRI Returns	NIFTY Returns	COMDEX Returns	NIFTY Returns	ENERGY Returns	NIFTY Returns	METAL Returns	NIFTY Returns
ω_i	-2.7506* (-30.320)	-0.339971* (-10.5930)	-0.385037* (-9.026742)	-0.34689* (-10.5431)	-0.271528* (-8.206679)	-0.348922* (-10.54864)	-0.279862* (-9.865811)	-0.348462* (-10.62903)
ψ_i	0.0517* (5.504262)	0.192671* (14.48622)	0.154970* (13.55131)	0.19645* (14.56605)	0.255035* (15.38065)	0.197015* (14.72284)	0.148920* (12.96297)	0.197215* (14.33432)
τ_i	-0.02026** -2.369856)	-0.085888* (-9.05312)	-0.02145** (-2.078928)	-0.08788* (-9.20330)	-0.050767* (-5.167291)	-0.087990* (-9.040263)	-0.01698** (-2.50821)	-0.087806* (-9.153385)
α_i	0.977595* (73.97087)	0.9723* (329.3744)	0.969683* (225.4350)	0.977123* (321.2404)	0.987350* (276.6799)	0.976941* (317.0847)	0.981105* (355.3390)	0.977013* (321.5718)
γ_i	1.169152 (0.962265)	-18.76019* (-42.5413)	-5.171464* (-7.691952)	0.320173** (2.441451)	-6.321513* (-7.570277)	0.136378 (0.392207)	-0.046179 (-0.556331)	0.235339** (2.374456)
Inferenc	AGRI→NIFTY		COMDEX↔NIFTY		NIFTY→ENERGY		METAL→NIFTY	
Residual Diagnostics								
ARCH-L Statistics	0.5551 [0.4563]	0.6320 [0.426	0.78143 [0.1242	0.712910 [0.39	0.2118 [0.645	0.7327 [0.392	0.6635 [0.415	0.7414 [0.3892]

Notes: () and [] -Figures in parenthesis are z-statistics and probability value, respectively. * and **- denote the significance at one and five percent level, respectively. ARCH-LM is a Lagrange Multiplier test examines the null hypothesis of ARCH effects in the residua (Engle, 1982).

The empirical evidence from Table 7.6 reveals that the GARCH effects (measured by α_i) for all the MCX commodity markets and NSE-NIFTY market are statistically significant, implying the degree of volatility persistence exists in the case of both MCX commodity markets and NSE-NIFTY markets. The outcomes indicate that after a surprise occurrence happens in the MCX commodity markets and NSE-NIFTY markets, its effects persists in

the markets for a considerable period of time. The leverage parameters (τ_i) that produce such outcomes are found to be significant statistically for both the MCX commodity markets and NSE-NIFTY market returns implying presence leverage effect. This implies that negative shock effects create much more increased levels of volatility when compared to positive shocks of the identical magnitude in the case of respective markets that belongs to NSE-NIFTY, MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL respectively.

Most importantly, the study outcomes indicate differing presence of spillover effect. The outcome between NSE-NIFTY and MCX-AGRI reveal that spillover takes place from MCX-AGRI market to NSE-NIFTY market prices. The outcome imply that specific information spillover is present from MCX-AGRI market to NSE-NIFTY market and the MCX-AGRI market through innovations possesses the means to uncover extensive quantum of up to date information.

Bidirectional spillover causes which are present between NSE-NIFTY market and MCX commodity markets, namely, METAL and COMDEX Markets has been confirmed by Bivariate EGARCH model. This reveals that commodity markets (METAL and COMDEX) and NSE-NIFTY markets through innovations possesses the means to uncover extensive quantum of up to date information.

The outcomes of Bivariate EGARCH model specify the spillover causes which occurs from NSE NIFTY market to MCX ENERGY market prices. The outcome indicates that there is specific information spillover taking place from NSE NIFTY market to MCX ENERGY market and the NSE NIFTY market through innovations possesses the means to uncover extensive quantum of up to date information.

By and large, it is clear that the study results reveal mixed evidence in the case of volatility spillover with reference to NSE-NIFTY and MCX commodity markets. The variation of spillover effect from one market to another is due to the fact that the selected indices are widely dispersed in terms of its industry-specific activities and also they are subject towards prevailing relative proportion of informed to uninformed (noise) traders migrating from the NIFTY to the Commodity markets.

To verify the effectiveness of Bivariate EGARCH outcomes with respect to NSE-NIFTY and MCX commodity markets, the ARCH-LM (Engle, 1982) test outcomes imply the reasonableness and correctness of the Bivariate EGARCH model to emphasise the time varying volatility (ARCH) impacts in the scrutinised time series for NSE-NIFTY and MCX commodity markets.

CHAPTER 8

LINKAGES AND VOLATILITY SPILLOVER AMONG MCX COMMODITY MARKETS AND BSE SENSEX MARKET

8.1 Introduction:

This chapter investigates the linkages and volatility spillover among the MCX commodity markets and BSE SENSEX market. The commodity markets considered for the study are MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and the equity market considered is BSE SENSEX market.

It evaluates whether there is unidirectional flow of information from the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the BSE SENSEX equity market, or BSE SENSEX equity market to the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL market or a bidirectional flow of information between these markets. The results help to identify the extent of linkages between the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the BSE SENSEX equity market and the speed of adjustments between the markets. Further, the study evaluates whether the volatility spills over from the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL to the BSE SENSEX equity market or BSE SENSEX market to the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL market or a bidirectional flow of volatility between the two markets.

8.2 Descriptive Statistics:

Table- 8.1 Descriptive Statistics of MCX Commodity Markets Return and BSE SENSEX Market Return

Statistics	MCXAGRI	MCXCOMDEX	MCXENERGY	MCXMETAL	BSE SENSEX
Mean	0.0003	0.0002	0.0000477	0.0004	0.0005
Std. Dev.	0.0082	0.0123	0.0283	0.0126	0.0158
Skewness	-1.5675	-0.0582	0.0646	-0.9244	0.1188
Kurtosis	169.73	37.654	238.69	13.322	11.022
Jarque-Bera Statistics	2782326* (0.000)	120144* (0.000)	5557564* (0.000)	11001* (0.000)	6444* (0.000)
Observations	2401	2401	2401	2401	2401
Notes: * – indicates significance at one per cent level. Probability Values are in Parenthesis.					

Table 8.1 presents the descriptive statistics of the MCX commodity markets return and BSE-SENSEX market return. The average closing prices of the MCXMETAL and MCXAGRI are higher than the MCXCOMDEX and MCXENERGY markets. On the other hand, the average returns of BSE-SENSEX are more than the averages return of MCX commodity markets during the study period. All commodity markets and equity market reflecting the standard deviation ranges between 0.0082 and 0.0158.

8.3 Unit Root Test:

Table- 8.2 Results of Unit Root Test

Name of Market	Levels	First Difference
Augmented Dickey-Fuller Test		
MCXAGRI	-1.5327	-44.277*
MCXCOMDEX	-2.0729	-51.644*
MCXENERGY	-2.2645	-62.688*
MCXMETAL	-2.2619	-50.418*
BSESENSEX	-2.1881	-45.870*
Philips-Perron Test		
MCXAGRI	-1.5208	-44.929*
MCXCOMDEX	-2.0722	-51.589*
MCXENERGY	-2.2331	-63.785*
MCXMETAL	-2.2609	-50.398*
BSESENSEX	-2.2101	-45.778*

Notes: * – indicates significance at one per cent level. Optimal lag length is determined by the Schwarz Information Criterion (SIC) for the Augmented Dickey-Fuller Test and Philips-Perron Test.

Table 8.2 shows the results of ADF and PP unit root test. The ADF and PP test statistics are shown for the log price series and the return series for indices of commodity markets viz. MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. BSE-SENSEX market. Based on Schwarz information criteria, the optimal lag length is chosen for ADF and PP tests. The ADF and PP test statistics for the commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and equity market, viz. BSE-SENSEX market indicate that the log price series of all markets contain unit root, implying the fact that both the commodity and equity prices series of MCX and BSE are non stationary, respectively. The ADF and PP test statistics reject the hypothesis of a unit root in return series, implying the fact that the return series are stationary.

8.4 Johansen Cointegration Test:

Once the MCX commodity markets and BSE-SENSEX market price series of each commodity are integrated at same order, the Cointegration test is employed to confirm the presence of long-term linkage involving MCX commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively and BSE-SENSEX equity market. The Johansen Cointegration is sensitive to the selection of optimal lag length and the necessary lag length of commodity and equity price series for the respective indices is determined by the Schwarz Information Criterion (SIC) and it reveals optimal lag of two for selected commodity markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and equity market, viz. BSE-SENSEX, respectively. **(Refer Annexure 4- Results of VAR Lag Length Selection)**

Johansen's cointegration test was performed to examine the long-run relationship between the MCX commodity markets and BSE-SENSEX equity market and its results are presented in Table- 8.3.

Table- 8.3 Results of Johansen Cointegration Test

Name of the Markets	vector (r)	Trace test Statistics (λ_{trace})	Maximal Eigen value (λ_{max})	5 % Critical value for Trace Statistics	5 % Critical value for Max-Eigen Statistics	Remarks
MCXAGRI & BSESENSEX	H_0: r = 0	21.727**	17.675**	20.261	15.892	*Cointegrated*
	H_1: r ≥ 1	2.0525	2.0525	9.1645	9.1645	
MCXCOMDEX & BSESENSEX	H_0: r = 0	19.915**	16.189**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	3.7263	3.7263	3.8414	3.8414	
MCXENERGY & BSESENSEX	H_0: r = 0	19.149**	15.780**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	2.3688	2.3688	3.8414	3.8414	
MCXMETAL & BSESENSEX	H_0: r = 0	17.297**	16.719**	15.494	14.264	*Cointegrated*
	H_1: r ≥ 1	2.5778	2.5778	3.8414	3.8414	

Notes: ** – indicates significance at five per cent level. The significant of the statistics is based on 5 per cent critical values obtained from Johansen and Juselius (1990). r is the number of cointegrating vectors. H_0 represents the null hypothesis of presence of no cointegrating vector and H_1 represents the alternative hypothesis of presence of cointegrating vector.

The results of Johansen's maximum eigen (λ_{max}) and trace statistics (λ_{trace}) indicate the presence of one cointegrating vector between the MCX commodity markets viz. MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and BSE-SENSEX equity market prices at 5% level respectively. The outcomes indicate the existence of at least one cointegration equation among MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL and BSE-SENSEX equity market prices, respectively. The empirical results found that there exists long-term equilibrium relationship between MCX commodity markets and BSE equity prices. The null hypothesis of no cointegration is rejected which reveals that one cointegration relationship exists between MCX commodity markets and BSE equity prices. Thus, the selected MCX commodity markets and BSE equity prices share common long-run information.

8.5 Vector Error Correction Model (VECM):

The VECM results are reported in Table- 8.4. It shows the short-run and long-run dynamics between the two markets. The lag length of the series is selected for Vector Error Correction Model (VECM) on the basis of Schwarz Information Criteria (SIC). The table result shows that coefficients of error correction terms (ECTs) in the BSE-SENSEX equations are statistically significant and also the coefficients of the ECTs in the MCXAGRI, MCXCOMDEX and MCXENERGY equations are found to be statistically significant, suggesting a bidirectional error correction. This indicates bidirectional relationship between the MCX commodity prices of MCXAGRI, MCXCOMDEX and MCXENERGY and BSE-SENSEX market prices in the long-run.

For MCXMETAL, the Error Correction coefficient (ECT) in the MCX commodity equation is statistically significant; while the coefficient of the ECT in the BSE-SENSEX equation is found to be statistically insignificant, suggesting a unidirectional error correction. This indicates that the BSE-SENSEX price leads the MCXMETAL commodity prices in the long-run.

Besides, the empirical evidence indicates that the lagged coefficient of changes in MCXAGRI prices in BSE-SENSEX equation is found to be statistically significant, whereas, the lagged coefficients of changes in BSE-SENSEX prices in MCXAGRI equations are found to be statistically insignificant, implying that unidirectional causation runs from MCXAGRI prices to BSE-SENSEX prices in the short-run.

For MCXMETAL and MCXCOMDEX, the lagged coefficient of changes in MCX prices in BSE-SENSEX equations are found to be statistically significant, as well as the lagged coefficients of changes in BSE-SENSEX prices in MCX price equations are found to be statistically significant, implying that bidirectional causation exists among MCXMETAL prices and BSE-SENSEX prices, and MCXCOMDEX prices and BSE-SENSEX prices in the short-run.

In addition, the empirical evidence indicates that the lagged coefficient of changes in BSE-SENSEX prices in MCXENERGY equation is found to be statistically significant, whereas, the lagged coefficients of changes in MCXENERGY prices in BSE-SENSEX equation are found to be statistically insignificant, implying that unidirectional causation runs from BSE-SENSEX prices to MCXENERGY prices in the short-run.

By and large, the evidences from VECM estimates show mixed evidence in the short-run and those are consistent with the findings of VECM estimates for BSE-SENSEX. Unidirectional causation runs from MCXAGRI prices to BSE-SENSEX prices in the short-run. Bidirectional causation exists among MCXMETAL prices and BSE-SENSEX prices, and MCXCOMDEX prices and BSE-SENSEX prices in the short-run. And unidirectional causation runs from BSE-SENSEX prices to MCXENERGY prices in the short-run.

The BSE-SENSEX prices lead the MCXMETAL price in the long-run. And bidirectional relationship between the MCX commodity markets prices of MCXAGRI, MCXCOMDEX and MCXENERGY and BSE-SENSEX market prices in the long-run.

Table- 8.4 Results of Vector Error Correction Model for MCX Commodity Markets and BSE-SENSEX Market

	MCXAGRI & SENSEX		MCXCOMDEX & SENSEX		MCXENERGY & SENSEX		MCXMETAL & SENSEX	
	ΔB_t	ΔC_t	ΔB_t	ΔC_t	ΔB_t	ΔC_t	ΔB_t	ΔC_t
ECT	-0.0046* (0.0015) [-3.0329]	-0.0013*** (0.0008) [-1.6686]	-4.46E-05*** (2.6E-05) [-1.7342]	-3.98E-05** (2.0E-05) [-1.99168]	-0.0003** (0.0001) [-2.2057]	-0.0006** (0.0003) [-1.9768]	0.0005 (0.0004) [1.2306]	0.0007** (0.0003) [2.4048]
ΔB_{t-1}	0.0695* (0.0204) [3.4069]	0.0108 (0.0106) [1.0165]	0.0726* (0.0206) [3.5233]	0.0664* (0.0160) [4.1520]	0.0688* (0.0205) [3.3499]	0.0770** (0.0356) [2.1596]	0.0746* (0.0205) [3.6273]	0.0924* (0.0163) [5.6537]
ΔB_{t-2}	-0.0282 (0.0204) [-1.3828]	-0.0036 (0.0106) [-0.3457]	-0.0290 (0.0206) [-1.4035]	-0.0078 (0.0160) [-0.4879]	-0.0289 (0.0205) [-1.4072]	0.0102 (0.0357) [0.2882]	-0.0275 (0.0206) [-1.3298]	0.0027 (0.0164) [0.1669]
ΔC_{t-1}	-0.0559*** (0.0291) [-1.7293]	0.0960* (0.0204) [4.6891]	-0.0548** (0.0265) [-2.0684]	-0.0636* (0.0206) [-3.0905]	-0.0136 (0.0118) [-1.1503]	-0.2582* (0.0205) [-12.554]	-0.0721* (0.0258) [-2.7891]	-0.0448** (0.0205) [-2.1806]
ΔC_{t-2}	0.0141 (0.0391) [0.3617]	0.0163 (0.0204) [0.7991]	0.0136 (0.0265) [0.5140]	0.0078 (0.0205) [0.3811]	-0.0068 (0.0118) [-0.5745]	-0.0526* (0.0205) [-2.5782]	0.0317 (0.0257) [1.2312]	-0.0235 (0.0204) [-1.1499]
C	0.0005*** (0.0003)	0.0003*** (0.0001)	0.0005*** (0.0003)	0.0002 (0.0002)	0.0005*** (0.0003)	2.30E-05 (0.0005)	0.0005*** (0.0003)	0.0004 (0.0002)

	[1.7873]	[1.8992]	[1.772]	[1.0403]	[1.7478]	[0.0410]	[1.7850]	[1.5788]

Notes: Optimal lag length is determined by the Schwarz Information Criterion (SIC), B_t and C_t are the BSE-SENSEX and MCX-Commodity markets price respectively. *, ** and *** denote the significance at the one, five and ten per cent level, respectively. [ ] & ( ) - Parenthesis shows t-statistics and standard error, respectively.

II Volatility Spillover

8.6 ARCH-LM Test:

Furthermore, the Engle (1982) ARCH-LM test statistics was conducted in order to test the null hypothesis of no ARCH effects on the commodity markets returns of MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. BSE-SENSEX market and its results are reported in the Table- 8.5.

Table- 8.5 ARCH LM Test Results of MCX Commodity Markets Return and BSE-SENSEX Market Return

Name of the Commodity	ARCH LM Statistics	
	Spot Returns	Prob. Value
MCXAGRI	45.324	0.000
MCXCOMDEX	630.67	0.000
MCXENERGY	664.65	0.000
MCXMETAL	99.636	0.000
BSE-SENSEX	53.370	0.000

The test statistics are highly significant at one percent levels, confirming the existence of significant ARCH effects on the commodity markets returns of MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL and equity market, viz. BSE-SENSEX market.

Figure 8.1: Volatility Clustering of Commodity Market Returns of MCXAGRI and BSE-SENSEX Return

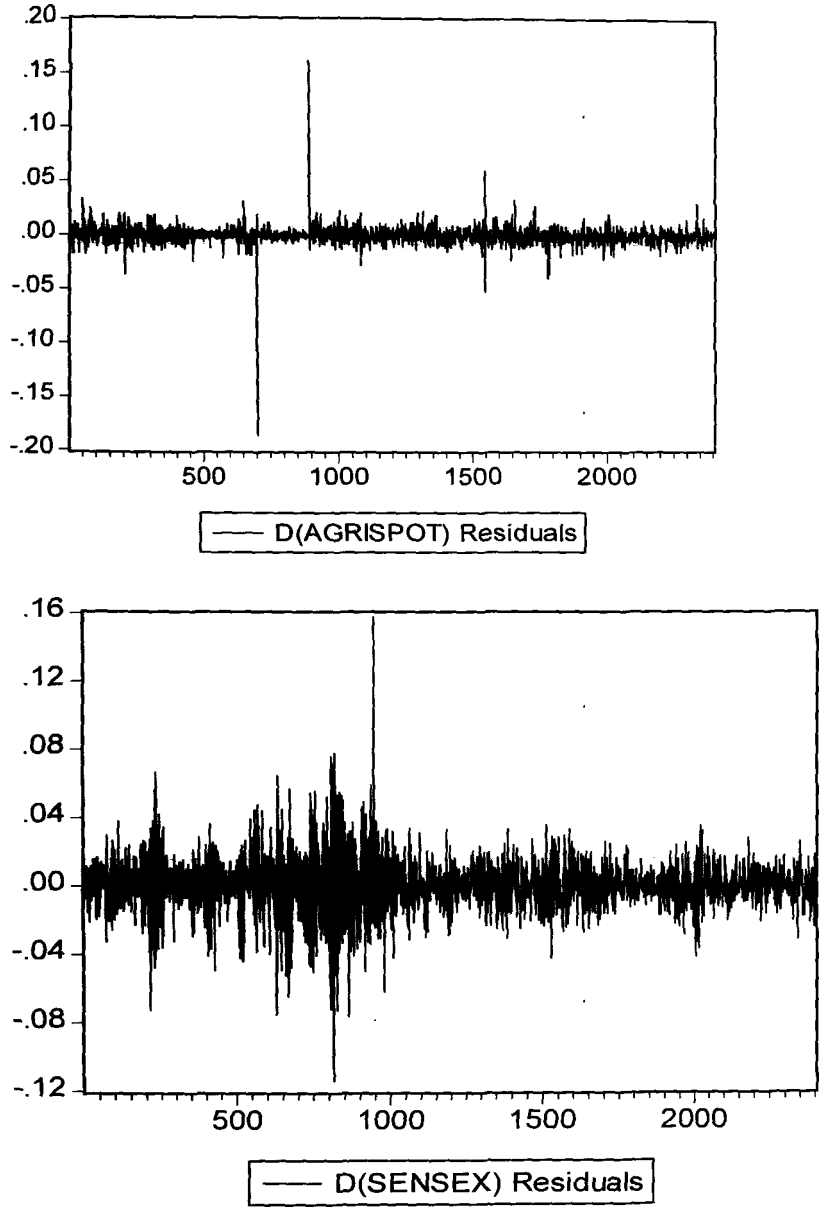
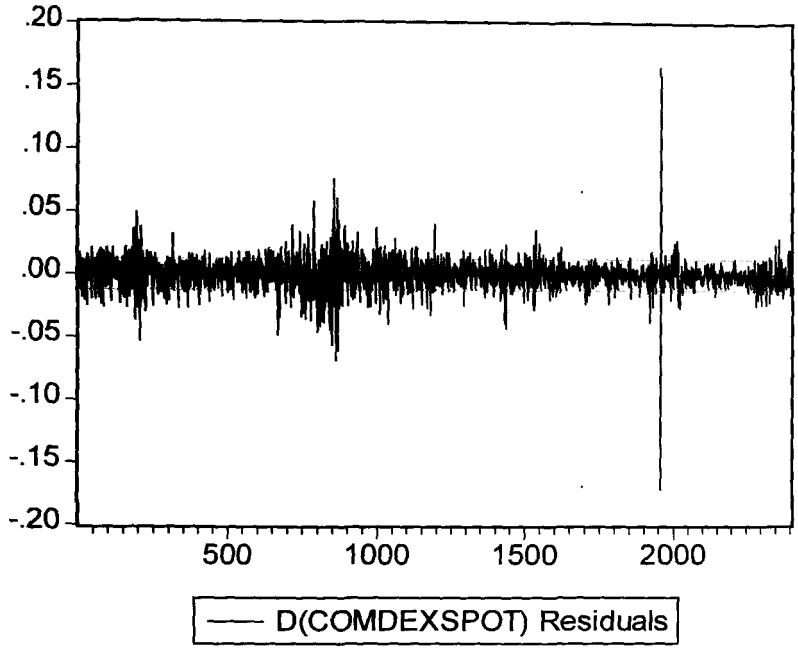


Figure 8.2: Volatility Clustering of Commodity Market Returns of MCXCOMDEX and BSE-SENSEX Return



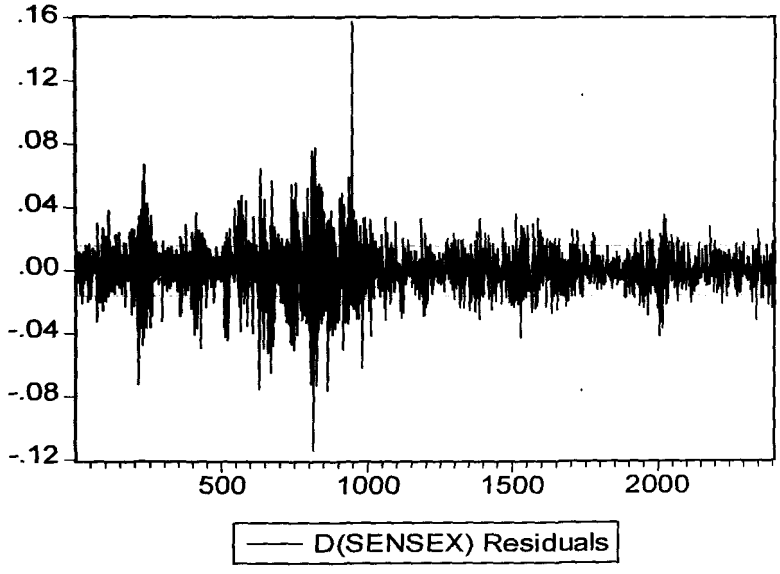
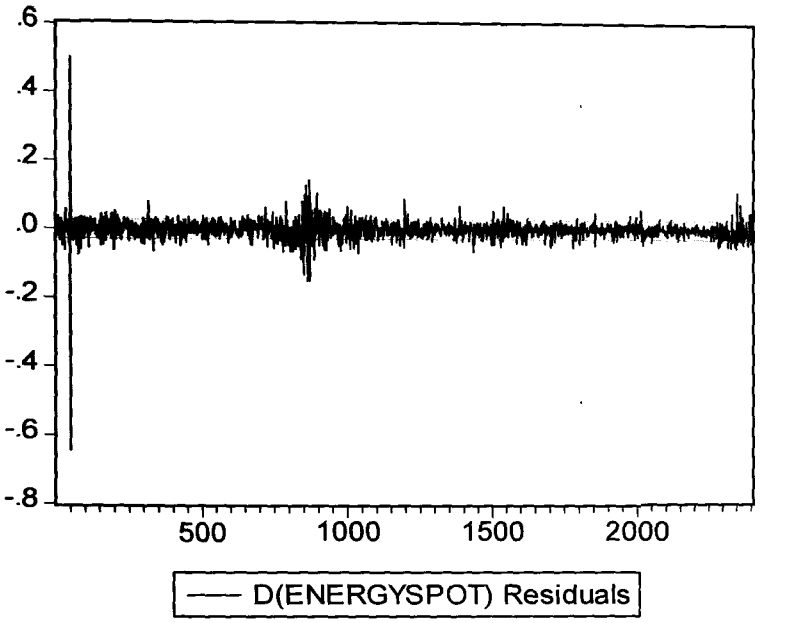


Figure 8.3: Volatility Clustering of Commodity Market Returns of MCXENERGY and BSE-SENSEX Return



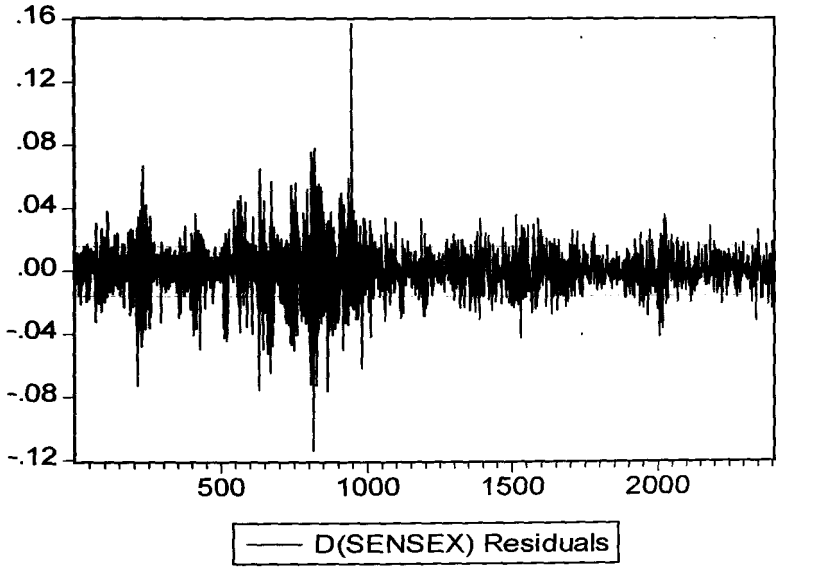
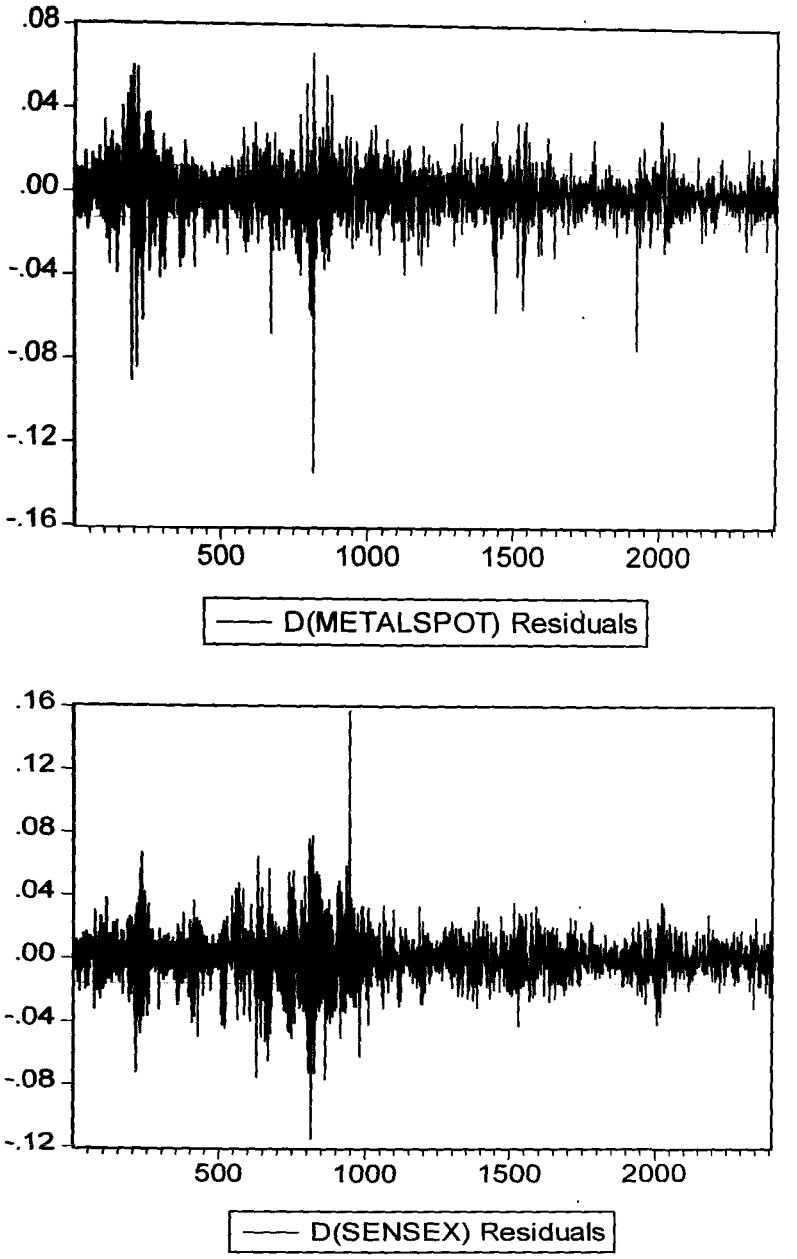


Figure 8.4: Volatility Clustering of Commodity Market Returns of MCXMETAL and BSE-SENSEX Return



Besides, Figure 8.1 to 8.4 shows the volatility clustering of BSE-SENSEX and MCX commodity markets returns, namely MCXCOMDEX, MCXAGRI, MCXENERGY and MCXMETAL. The graphical representation of the residuals obtained from the BSE-SENSEX and MCX commodity markets returns exhibits significant ARCH effects i.e. volatility clustering or volatility persistence. This suggests that Bivariate EGARCH model

adequately maps the heteroscedastic impact and volatility clustering to enable modelling of the return volatility of BSE-SENSEX and MCX commodity markets returns.

8.7 Bivariate EGARCH Model:

The table 8.6 shows the Bivariate EGARCH model which estimates the presence of volatility spillover systems in the commodity markets of MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively and BSE-SENSEX market specifying the presence of persistence degree of volatility with respect to MCX commodity markets and BSE-SENSEX market.

Table- 8.6 Results of Volatility Spillover for the MCX Commodity Markets Return and BSE-SENSEX Market Return

Parameters	AGRI Returns	SENSEX Returns	COMDEX Returns	SENSEX Returns	ENERGY Returns	SENSEX Returns	METAL Returns	SENSEX Returns
ω	-2.796912* (-39.92548)	-0.305689* (-10.51595)	-0.389151* (-8.963192)	-0.312665* (-10.31770)	-0.285386* (-8.427456)	-0.318473* (-10.34901)	-0.282032* (-9.987676)	-0.313058* (-10.40985)
υ	0.066951* (6.905676)	0.179493* (14.11334)	0.154001* (13.37666)	0.184386* (14.26302)	0.257290* (15.33648)	0.186052* (14.39282)	0.148847* (13.01380)	0.185341* (14.16219)
τ	-0.160870* (-2.715116)	-0.075167* (-8.193531)	0.021648* (2.070379)	-0.077918* (-8.417989)	0.051878* (5.206017)	-0.078316* (-8.200999)	0.017342** (2.549942)	-0.077506* (-8.352161)
α	0.716248* (95.22924)	0.980413* (372.1361)	0.969133* (221.4468)	0.980032* (356.7251)	0.985780* (267.5263)	0.979517* (347.3742)	0.980861* (356.4433)	0.980071* (359.2254)
ϑ	0.006569 (1.417755)	-19.33341* (-49.36749)	-4.876096* (-7.287795)	0.961312** 1.977394	-6.901085* (-8.379350)	0.278205 (0.857469)	0.866204 (1.392836)	-2.762278* (-6.874695)
Inference	AGRI→ SENSEX		COMEX↔ SENSEX		SENSEX →ENERGY		METAL→ SENSEX	
Residual Diagnostics								
ARCH-LM Statistics	0.474765 [0.4908]	1.030344 [0.3101]	0.86176 [0.1191]	1.105423 [0.2931]	0.2052 [0.6505]	1.202168 [0.2729]	0.672226 [0.4123]	1.150970 [0.2834]

Notes: () and [] -Figures in parenthesis are z-statistics and probability value, respectively. * and **- denote the significance at one and five percent level, respectively. ARCH-LM is a Lagrange Multiplier test examines the null hypothesis of ARCH effects in the residuals (Engle, 1982).

The empirical evidence from Table 8.6 reveals that the GARCH effects (measured by α_i) for all the MCX commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively and BSE-SENSEX market specifying the presence of persistence degree of volatility with respect to MCX commodity markets and BSE-SENSEX market. The outcome indicate that after a surprise occurrence happens in

the MCX commodity markets and BSE-SENSEX market, its effects persists in the markets for a considerable period of time. The parameters that produce such outcomes are found to be significant statistically for both the MCX commodity markets and BSE-SENSEX market returns.

The leverage effect parameters (τ_i) are statistically significant for both MCX commodity markets and BSE-SENSEX market returns, indicating existence of leverage effect. It specifies the presence of leverage causes. It also becomes obvious that shock effects of conditional volatility impact the markets much more significantly as compared to positive shock effects of an identical magnitude as in the markets that belong to BSE-SENSEX, MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL, respectively. It also becomes obvious that negative shock effects of conditional volatility impact the markets much more significantly as compared to positive shocks effects of an identical magnitude. Most importantly, Table- 8.6 outcomes show mixed evidence in the case of spillover effect. The Bivariate EGARCH Model outcomes suggest divergent presence of spillover causes. The outcomes between BSE-SENSEX and MCXAGRI reveal that spillover takes place from MCXAGRI market to BSE-SENSEX market prices. The outcomes specify that there is information spillover happening from MCXAGRI market to BSE-SENSEX market and the MCXAGRI market through innovations possesses the means to uncover extensive quantum of up to date information.

The outcomes of Bivariate EGARCH model reassure that there is presence of bidirectional spillover among BSE-SENSEX market and MCX markets, namely, METAL and COMDEX Markets. This reveals that commodity markets (METAL and COMDEX) and BSE-SENSEX through innovations possesses means to uncover extensive quantum of up to date information.

Besides, the result confirms that there is spillover taking place from BSE-SENSEX to ENERGY market prices. The outcomes indicate that information spillover takes place from BSE-SENSEX market to ENERGY market and the BSE-SENSEX market and BSE-SENSEX market through innovations possesses the means to uncover extensive quantum of up to date information.

On the whole, from the study results, it is clear that the study results reveal mixed evidence in the case of volatility spillover with reference to BSE-SENSEX and MCX commodity markets. The variation of spillover effect from one market to another is due to the fact that the selected indices are widely dispersed in terms of its industry-specific activities and also they are subject towards prevailing relative proportion of informed to uninformed (noise) traders migrating from the BSE-SENSEX to the Commodity markets.

To verify the effectiveness of Bivariate EGARCH outcomes with respect to BSE-SENSEX and MCX commodity markets, the outcomes imply the reasonableness and correctness of the Bivariate EGARCH model to emphasise the time varying volatility (ARCH) impacts in the scrutinised time series for BSE-SENSEX and MCX commodity markets.

CHAPTER 9

CONCLUSION

9.1 Findings of the Study:

The present research study analysed the present status, trading patterns and trends in the commodity derivatives market in India. The study investigated the price discovery and volatility spillover in the commodity spot and futures market. The study also investigated the price discovery and volatility spillover in individual commodities spot and futures prices in the MCX and NCDEX commodity markets. The study further analysed the linkages and volatility spillover among the commodity markets and equity markets in India.

The following are the major findings of the study;

Present Status, Trading Pattern and Trends in Indian Commodity Derivatives Market

1. The consistent growth witnessed in Indian commodity derivative market since the year 2002-03 has continued over the years. The sum total of trading has shown an increasing trend having reached its peak to Rs.181.26 lakh crores in 2011-2012. The trading dropped marginally in the year 2014-2015 on account of NSEL payment crises and introduction of Commodity Transaction Tax (CTT) on commodity trading.

2. The growth witnessed in trading has been primarily propelled by National Commodity Exchanges more specifically Multi Commodity Exchange (MCX) Mumbai, and National Commodity Derivatives Exchange (NCDEX) Mumbai accounting for a bigger chunk of market share. MCX emerged as the largest commodity derivatives exchange followed by NCDEX in the commodity derivatives market in India. As the largest commodity exchange in India, the growth of MCX is comparable with some of the international commodity derivatives exchanges. Even though there are 22 commodity exchanges in India, the six major national exchanges accounted for more than 99% of the total value of trade.

3. Initially when commodity derivatives trading got introduced the major share of trading was in agriculture followed by bullion and metals. Subsequently from 2005-06 onwards till 2007-08, major trading was in bullion followed by agriculture, energy and metals. From 2008-09 to 2011-12 bullion retained its highest percentage share of the commodities traded in all commodity derivatives exchanges in India followed by metals, energy and agriculture. Since 2012-13 till the year 2015-16 the major share has been retained by bullion followed by energy, metals and agriculture. Even though India is an agricultural surplus economy, trading in non-agricultural commodities have dominated since the year 2005-06 and onwards

4. MCX has majority trading in non- agricultural commodities with gold, silver, crude oil, copper and natural gas accounting for the major share of the commodities being traded at MCX. Globally, MCX ranks number one in silver, number two in natural gas, number three in crude oil and gold futures trading. NCDEX is known more for trading in agricultural commodities with soya oil, soyabean, chana, castor seeds and dhaniya accounting for the majority trading.

Price Discovery and Volatility Spill over in the Spot and Futures Commodity Markets, viz. MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL

5. Johensen test of cointegration test confirmed the presence of long term equilibrium relationship between spot and futures price series in case of all the selected commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL. Cointegration analysis measures the extent to which two markets have achieved long run equilibrium. Efficiency can be concluded because future prices and spot prices are cointegrated in all the selected commodities since cointegration is a necessary condition for market efficiency.

6. Vector Error Correction Model results evidenced that futures and spot prices of select commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL lead lag together in the long term. VECM estimates show that unidirectional causation runs from futures prices to spot prices in the long-run for commodity markets implying that futures market plays a dominant role. In addition, there exists bidirectional relationship between spot and futures markets price in the short-run, implying that both spot and futures markets are informationally efficient and play a dominant role as effective price discovery vehicles in the short-run.

7. Bivariate EGARCH model outcomes across commodity markets namely MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL confirm the presence of persistence degree of volatility with respect to both spot as well as futures market returns of commodity markets. The EGARCH result shows that the bidirectional spillover exists between the spot market and futures commodity markets. Despite of bidirectional spillover exists among futures and spot market for all commodity markets, the spillover effect from futures to spot is more than that of spot to futures market. Therefore, the evidences from Bivariate EGARCH show that volatility spillover effect exists from futures to spot market.

Price Discovery and Volatility Spillover in Spot and Futures Prices of Individual Commodities in MCX and NCDEX

8. Johansen's Cointegration test was used which confirmed the long term association between futures and spot market prices in forty five commodities across the sectors namely Agriculture, Bullion, Energy and Metals having very significant consequences on traders who trade in the futures market. The detection of cointegration between the markets implies that even though there is no equilibrium between the two markets in the short term, any deviation that may occur will get corrected in the long term promptly during the process of

arbitrage and the underlying market risk may be hedged to the greatest possible degree by hedgers taking up extended period positions.

9. On the whole, from the VECM results, it is clear that the unilateral causation runs from futures market price to spot market price in majority of the underlying stocks that belong to Agriculture and Energy sector. And Bullions show mixed evidence. Bidirectional relationship exists between spot and futures market prices in majority of the Metals commodities.

10. The Bivariate EGARCH model indicates the presence of persistence degree of volatility with respect to both spot as well as futures market returns of the selected stocks which belong to Bullion, Agriculture, Energy and Metal. The results indicate that unilateral spillover runs from futures market price to spot market price in majority of the commodities that belong to Agriculture and Energy sector. And Bullions show mixed evidence. Following this, the feedback spillover effect exists between spot and futures market prices in majority of the underlying stocks that belongs to Metals.

11. The variation of price discovery and volatility spillover mechanism from one commodity to another is due to the fact that the selected commodities from different industry groups are widely dispersed in terms of its industry-specific activities and also they are subject towards prevailing differential market frictions such as transaction costs, initial margin requirements, leverage positions and flexibility of short positions and liquidity differences between spot and futures markets. Besides, the present study suggests that depending on the relative proportion of informed to uninformed (noise) traders migrating from the spot market to the futures market, the lead-lag relationship and spillover

effects between futures and spot market of selected commodities of respective industry groups may differ.

Linkages and Volatility Spillover among MCX Commodity Markets and NSE-NIFTY Market

12. The Johensen Julius test of Cointegration confirms the presence of extended term linkage involving MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL markets and NSE-NIFTY equity market. The empirical results found that there exists long-term equilibrium relationship between MCX commodity markets and NSE NIFTY equity prices in the case of all the selected indices. Thus, the selected MCX and NSE-NIFTY equity prices share common long-run information.

13. The VECM results show mixed evidence in the short-run and long-run dynamics between the two markets. The MCXAGRI commodity price leads the NSE-NIFTY price in the long-run. NSE-NIFTY price leads the MCXMETAL and MCXCOMDEX commodity prices in the long-run. Besides, bidirectional relationship between the MCXENERGY and NSE-NIFTY market prices in the long-run. Unidirectional causation runs from MCXAGRI prices to NSE-NIFT prices in the short-run. Bidirectional causation exists among MCXMETAL prices and NSE-NIFTY prices, and MCXCOMDEX prices and NSE-NIFTY prices in the short-run. And unidirectional causation runs from NSE-NIFTY prices to MCXENERGY prices in the short-run.

14. The empirical evidence from the Bivariate EGARCH model reveal mixed evidence in the case of volatility spillover with reference to NSE-NIFTY and MCX commodity markets. Most importantly, the study outcomes indicate differing presence of spillover effect. The outcome between NSE-NIFTY and MCX-AGRI reveal that spillover takes

place from MCX-AGRI market to NSE-NIFTY market prices. Bidirectional spillover causes which are present between NSE-NIFTY market and MCX markets, namely, METAL and COMDEX Markets has been confirmed by Bivariate EGARCH model. The outcomes of Bivariate EGARCH model specify the spillover causes which occurs from NSE NIFTY market to MCX ENERGY market prices.

Linkages and Volatility Spillover among MCX Commodity Markets and BSE-SENSEX Market

15. The Johensen Julius test of Cointegration confirms the presence of extended term linkage involving MCXAGRI, MCXCOMDEX, MCXENERGY and MCXMETAL markets and BSE-SENSEX equity market. The empirical results found that there exists long-term equilibrium relationship between MCX and BSE equity prices in the case of all the selected commodities.

16. VECM results show that in the short-run unidirectional causation runs from MCXAGRI to BSE-SENSEX. Bidirectional causation exists among MCXMETAL and BSE-SENSEX, and MCXCOMDEX and BSE-SENSEX in the short-run. And unidirectional causation runs from BSE-SENSEX to MCXENERGY in the short-run. In the long-run BSE-SENSEX leads the MCXMETAL and there is bidirectional relationship between the MCXAGRI, MCXCOMDEX and MCXENERGY and BSE-SENSEX market in the long-run.

17. The Bivariate EGARCH model estimates the presence of volatility spillover systems in the MCX commodity markets and BSE-SENSEX market specifying the presence of persistence degree of volatility. The study results reveal mixed evidence in the case of volatility spillover with reference to BSE-SENSEX and MCX commodity markets. The variation of spillover effect from one market to another is due to the fact that the selected indices are widely dispersed in terms of its industry-specific activities and also they are

subject towards prevailing relative proportion of informed to uninformed (noise) traders migrating from the BSE-SENSEX to the Commodity markets.

Commodity Derivatives and Equity Market in India

18. The historic merger of FMC with SEBI has facilitated the convergence of regulatory framework and ensured vibrant securities market with efficient conduct of commodity derivatives market and introduction of new products. SEBI has made efforts to evolve new products and bring in market participants facilitating better liquidity. With steady and firm initiatives, SEBI has taken initiatives to see that the commodity derivatives market is developed like the securities market in terms of risk management, supervision, new products, investor protection, technology, surveillance etc.

19. The study has found that the commodity futures market is developing in the proper path as the futures market is playing crucial role in the process of transmission of information.

20. The Commodity derivative market has played a major role of performing two important functions of price risk management and price discovery. Since reintroduction of the commodity derivatives market in India from 2002-03 onwards, it has experienced an unprecedented boom in terms of the commodities permitted for trading, modern exchanges and value of trading.

21. The study has observed that even though more than 100 commodities are being traded on the commodity exchanges in actual practice only few commodities are traded more with trading taking place on few exchange which could be possibly avoided by consolidating exchanges.

22. Commodity derivatives market plays an important role in discovery of prices as it helps the producers to plan their activities on production, storage, marketing and processing of commodities.

23. As the futures market has the capability to increase the flow of information with the medium of new technology and other channels, the spot market through the volatility from futures market get its self exposed to the same. So the both the price discovery and volatility spillover are necessary for the proper functioning of the commodity derivative market.

24. The relationship between the commodity derivative market and equity market is effective which can be used to hedge or speculate the price movements. Forecasting of commodity and equity market prices can be undertaken by using the lead lag relationship between them.

25. The study has found the linkages between the commodity derivatives market and equity markets in India and that there exists opportunities to investors. The investors can benefit by diversifying their investments and minimizing the market risk.

9.2 Conclusion:

The commodity derivatives market in India has a long history of trading especially agricultural commodities and has been witness to several developments right from being protected through Government intervention especially the essential agricultural commodities and the liberalization of the futures trading since 2002-03. The true potential

and usefulness of commodity derivatives market is yet to be achieved in further developing the agricultural commodity market, especially in agricultural based economy like India.

Commodity derivatives markets play an important role in the efficient price discovery process. The Indian commodity derivative market can play a crucial role provided regulatory policies are flexible and market participants are aware about their existence. With SEBI as the new independent regulator with experience of successfully regulating the financial market in India, the commodity derivatives market is expected to achieve greater heights in the years to come.

The most common uncertainty in the commodity derivatives market is relating to certain contracts being delisted or banned, which requires policy changes to make the market more effective.

Most of the problems faced by the commodity derivatives market are common across the exchanges which call from the regulator, Government and the commodity exchanges to be focused and pragmatic in their approach in the form of policy changes to overcome the challenges and constraints facing the commodity derivatives market.

The empirical findings of the study show the role played by commodity derivatives market in disseminating information, in the form of price discovery and volatility spillover and the impact of commodity market on the equity market in India.

Given that the commodity derivatives trading has been reintroduced with lot of expectations the Government through the regulatory authorities and policies should support the commodity markets by providing fiscal incentives, sound regulatory environment,

infrastructure facilities and broad basing the commodity investors. Commodity market has wide implications on the Indian economy on issues relating to inflation, infrastructure development, wealth creation, employment generation, etc. Hence, the support from Government shall lead to growth in commodity market and overall economic development of the country.

9.3 Suggestions and Policy Recommendations:

1. As commodity derivatives market helps in the establishment of equilibrium in the prices, the authorities should not look at the futures market with skepticism.

2. The commodity market regulator has to reach out to farmers through the medium of post offices, banks and make efforts to disseminate future prices which would enable the farmers to take a call on the cropping patterns.

3. There is a need to provide infrastructure like warehouses, finance etc which would enable farmers to take a call on whether to sell or hold their output during harvesting time when prices tend to be low.

4. The relationship between the commodity derivative market and equity market is effective which can be used to hedge or speculate the price movements. Forecasting of commodity and equity market prices can be undertaken by using the lead lag relationship between them.

5. As Indian commodity derivatives markets grow more sophisticated, greater investor awareness will become essential for further development of the commodity derivatives market.

6. Efforts need be made to look at margin imposition system and reduce margins without compromising on the integrity of the commodity derivatives market. This would attract more participants to the commodity derivatives market.

7. Co-operation between regional and national level commodity exchanges would foster trade and free flow of business with encouragement from the commodity market regulator.

8. Introduction of position limits for traders would help to prevent excessive speculation in the commodity derivatives market.

9. Strengthening of surveillance system would facilitate early detection of anomalous trading behaviour in the commodity derivatives market.

10. Trained staff in commodity markets with training by the regulatory authorities would go a long way in development of the commodity markets.

11. Increasing the breadth and depth of the commodity derivatives market would facilitate participation of farmers, hedgers and financial institutions.

12. Commodity Transaction Tax should be earmarked and used for the development of commodity market infrastructure.

13. Banks and Financial Institutions should be allowed to participate in the commodity derivatives exchanges which are presently not permitted; now that mutual funds would be allowed by SEBI to invest and trade in commodity derivatives on exchanges.

14. Vibrant agricultural sector should attract investment for raising production and productivity which can act as a back bone for the commodity derivatives market.

15. Strong support of information and communication technology would further support the expansion of commodity derivatives market through introduction of commodity index futures, option trading etc.

16. There is a need to integrate commodity derivatives market with the underlying physical market which is a major hurdle in the development of commodity derivatives market.

17. Warehousing reforms with delivery centres and warehouse receipts would facilitate the trading participant in their financial needs. Only about 1% to 5% of total commodity derivatives being traded in India are settled in physical delivery on account of warehousing problems. As good delivery system is the back bone of any commodity trade, warehousing problem has to be handled on a war footing.

18. Options have to be introduced in commodity derivatives trading as derivatives market is not complete without the presence of this important derivative product to reap full benefits of hedging through derivatives.

19. There is a need for the reduction if not elimination of the Commodity Transaction Tax (CTT) which have been even advocated by the exchanges and market participants.

20. New product launches such as options and index trading should be introduced to drive future growth in the commodity derivatives market.

21. There is need to attract large scale broking firms who have diversified into stock broking and other related businesses to the commodity markets. Regulations like setting standards for brokers, imposing capital adequacy norms, qualification criterion, etc would become more meaningful when more and more active traders are attracted to the commodity markets.

22. Commodity derivatives are popular in only few commodities and most of the trade takes place on a few exchanges, resulting in volumes being split and making some exchanges unviable. This problem can possibly be addressed by consolidating some exchanges to bring in economies of scale and enhance their scope, thus boosting the growth of commodity derivatives market.

23. The restrictions on the movement of certain goods from one state to another needs to be removed so that a truly national market could developed. Further regulatory changes are required to bring about uniformity in the duties.

24. Concerted efforts need to be made to bring the traditional players to the formal market in order to achieve minimum critical liquidity, sufficient breadth and depth and provide relatively less expensive exit route. Lack of awareness about the role and technique of derivatives trading among the potential beneficiaries is hindering the growth of the commodity derivatives market.

25. Make in India presents commodity exchanges an interesting opportunity to grow business with increased manufacturing activity resulting in increased commodity exposure.

9.4 Scope for Further Research:

The current research study offers adequate scope for undertaking further research studies on related issues. The future research could cover comparisons made between the domestic commodity markets and other international commodity markets. Further the impact of shocks in the economy on the commodity market prices along with seasonality can also be covered in future research studies.

There is scope for further research to include more commodities, particularly from other commodity exchanges like NMCE, ICEX, ACE and UCEX. Moreover there is scope to analyse the impact of macroeconomic factors on commodity price volatility. The scope of the impact of commodity derivatives market on equity market in India could be widened by considering the other broad equity indices of both NSE and BSE.

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ANNEXURES

Annexure- 1 Results of VAR Lag Length Selection for Johensen Cointegration Test to examine the long-run relationship between MCX Spot and Futures Commodity Markets

VAR Lag Order Selection Criteria for AGRI-SPOT and AGRI-FUTURES						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	1361.702	--	0.0010	-1.1378	-1.1329	-1.1360
1	15135.08	27512.18	1.09e-08	-12.660	-12.645	-12.655
2	15182.21	94.066	1.05e-08	-12.696	-12.672	-12.687
3	15239.78	114.80	1.00e-08	-12.741	-12.707	-12.728
4	15255.78	31.882	9.94e-09	-12.751	-12.707*	-12.735*
5	15260.34	9.0823	9.93e-09	-12.751	-12.698	-12.732
6	15266.84	12.925*	9.91e-09*	-12.753*	-12.690	-12.730
7	15269.11	4.5079	9.93e-09	-12.752	-12.679	-12.726
8	15272.51	6.7564	9.93e-09	-12.751	-12.669	-12.721
9	15273.75	2.4552	9.95e-09	-12.749	-12.657	-12.716
10	15274.79	2.0514	9.98e-09	-12.747	-12.645	-12.710
11	15276.71	3.8202	1.00e-08	-12.745	-12.634	-12.704
12	15278.65	3.8303	1.00e-08	-12.743	-12.622	-12.699
VAR Lag Order Selection Criteria for COMDEX-SPOT and COMDEX-FUTURES						
0	5595.05	--	3.18e-05	-4.6803	-4.6755	-4.6786
1	14806.84	18400.43	1.43e-08	-12.385	-12.371	-12.380
2	14978.22	342.04	1.25e-08	-12.525	-12.501	-12.516
3	15171.97	386.38	1.06e-08	-12.684	-12.650	-12.672
4	15239.45	134.43	1.01e-08	-12.737	-12.694	-12.721
5	15276.72	74.197	9.80e-09	-12.765	-12.712	-12.746
6	15292.85	32.093	9.70e-09	-12.775	-12.712*	-12.752
7	15302.80	19.764	9.65e-09	-12.780	-12.708	-12.754
8	15314.98	24.185	9.58e-09	-12.787	-12.705	-12.757*
9	15322.61	15.137*	9.55e-09*	-12.790*	-12.698	-12.757
10	15324.34	3.4310	9.57e-09	-12.788	-12.687	-12.751
11	15327.24	5.7423	9.58e-09	-12.787	-12.676	-12.747
12	15327.46	0.4363	9.61e-09	-12.784	-12.663	-12.740
VAR Lag Order Selection Criteria for ENERGY-SPOT and ENERGY-FUTURES						
0	5221.20	--	4.35e-05	-4.3675	-4.3627	-4.3657
1	12044.65	13629.77	1.45e-07	-10.074	-10.059	-10.068
2	12085.94	82.392	1.40e-07	-10.105	-10.081	-10.096
3	12135.76	99.351	1.35e-07	-10.143	-10.109	-10.131
4	12155.57	39.469	1.33e-07	-10.156	-10.113	-10.141
5	12191.90	72.330	1.29e-07	-10.184	-10.130	-10.164
6	12207.84	31.700	1.28e-07	-10.194	-10.131*	-10.171
7	12222.43	29.008	1.27e-07	-10.202	-10.130	-10.176
8	12232.67	20.322	1.26e-07*	-10.208*	-10.125	-10.178*
9	12235.80	6.2067	1.26e-07	-10.207	-10.115	-10.173
10	12237.97	4.3144	1.27e-07	-10.205	-10.104	-10.168
11	12242.92	9.8045*	1.27e-07	-10.206	-10.095	-10.166
12	12244.28	2.6911	1.27e-07	-10.204	-10.083	-10.160
VAR Lag Order Selection Criteria for METAL-SPOT and METAL-FUTURES						
0	5615.56	--	3.13e-05	-4.6975	-4.6927	-4.6957
1	14207.18	17161.67	2.37e-08	-11.883	-11.869	-11.878
2	14225.22	35.994	2.34e-08	-11.895	-11.871	-11.886
3	14266.49	82.314	2.27e-08	-11.926	-11.892	-11.914
4	14298.77	64.310	2.21e-08	-11.950	-11.906	-11.934
5	14319.02	40.303	2.18e-08	-11.964	-11.910*	-11.944

6	14331.01	23.860	2.17e-08	-11.970	-11.907	-11.947
7	14332.79	3.5373	2.17e-08	-11.968	-11.896	-11.942
8	14348.93	32.046	2.15e-08	-11.979	-11.896	-11.949*
9	14355.94	13.904*	2.15e-08	-11.981	-11.889	-11.948
10	14360.67	9.3919	2.14e-08*	-11.982*	-11.880	-11.945
11	14364.44	7.4556	2.14e-08	-11.981	-11.870	-11.941
12	14366.06	3.2011	2.15e-08	-11.979	-11.859	-11.935

Notes: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (e test at 5% level). FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

Annexure- 2 Results of VAR Lag Length Selection for Johensen Cointegration Test to examine the long-run relationship between Individual Commodities Spot and Futures Prices

AGRICULTURE						
BARLEY						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	1809.906	NA	0.000582	-1.773326	-1.767813	-1.771304
1	11877.11	20104.79	3.01e-08	-11.64406	-11.62752*	-11.63799
2	11892.30	30.30200	2.97e-08	-11.65503	-11.62747	-11.64492
3	11905.08	25.47215	2.95e-08*	-11.66364*	-11.62505	-11.64949*
4	11906.09	2.007387	2.96e-08	-11.66071	-11.61109	-11.64251
5	11909.54	6.865963	2.96e-08	-11.66017	-11.59953	-11.63793
6	11909.87	0.658521	2.97e-08	-11.65657	-11.58491	-11.63028
7	11917.45	15.04811*	2.96e-08	-11.66008	-11.57739	-11.62975
8	11918.71	2.488834	2.97e-08	-11.65739	-11.56367	-11.62301
9	11918.90	0.377166	2.98e-08	-11.65365	-11.54891	-11.61523
10	11921.61	5.364031	2.98e-08	-11.65239	-11.53662	-11.60992
11	11925.86	8.400219	2.98e-08	-11.65263	-11.52584	-11.60612
12	11927.63	3.510862	2.99e-08	-11.65045	-11.51263	-11.59990
CASTOR SEEDS						
0	2748.342	NA	5.40e-05	-4.151689	-4.143846	-4.148749
1	7353.020	9188.474	5.15e-08	-11.10661	-11.08308*	-11.09779
2	7432.427	158.2141	4.59e-08	-11.22060	-11.18139	-11.20590
3	7446.255	27.50903*	4.52e-08*	-11.23546*	-11.18056	-11.21488*
4	7447.197	1.871859	4.55e-08	-11.23084	-11.16025	-11.20438
5	7451.797	9.122136	4.54e-08	-11.23174	-11.14548	-11.19940
6	7452.064	0.528488	4.57e-08	-11.22610	-11.12415	-11.18788
7	7454.488	4.793603	4.58e-08	-11.22372	-11.10608	-11.17962
8	7457.889	6.714942	4.58e-08	-11.22281	-11.08949	-11.17283
9	7462.544	9.175756	4.58e-08	-11.22380	-11.07480	-11.16794
10	7466.953	8.678300	4.57e-08	-11.22442	-11.05973	-11.16268
11	7470.050	6.085658	4.58e-08	-11.22305	-11.04268	-11.15544
12	7473.298	6.374389	4.59e-08	-11.22192	-11.02586	-11.14842
CHANNA						

0	2730.348	NA	0.000387	-2.180934	-2.176278	-2.179243
1	13956.97	22426.31	4.92e-08	-11.15185	-11.13788*	-11.14678
2	14073.46	232.5325	4.50e-08	-11.24178	-11.21850	-11.23333
3	14084.62	22.24631	4.47e-08*	-11.24750*	-11.21490	-11.23566*
4	14087.88	6.496678	4.47e-08	-11.24691	-11.20500	-11.23169
5	14092.44	9.072376	4.47e-08	-11.24735	-11.19613	-11.22876
6	14094.19	3.482955	4.48e-08	-11.24555	-11.18502	-11.22358
7	14097.10	5.795381	4.48e-08	-11.24469	-11.17484	-11.21933
8	14098.34	2.463090	4.49e-08	-11.24248	-11.16332	-11.21374
9	14102.46	8.170371	4.49e-08	-11.24257	-11.15410	-11.21046
10	14108.74	12.45720	4.48e-08	-11.24440	-11.14662	-11.20890
11	14113.83	10.09020*	4.48e-08	-11.24527	-11.13818	-11.20639
12	14116.74	5.754891	4.48e-08	-11.24439	-11.12799	-11.20214

CHILLI

0	982.3724	NA	0.001158	-1.085684	-1.079594	-1.083436
1	8421.732	14854.00	3.07e-07	-9.319747	-9.301479*	-9.313005
2	8478.832	113.8846	2.90e-07	-9.378552	-9.348104	-9.367314
3	8538.350	118.5735	2.72e-07	-9.440033	-9.397406	-9.424300*
4	8541.124	5.521322	2.73e-07	-9.438676	-9.383870	-9.418448
5	8544.687	7.082686	2.73e-07	-9.438192	-9.371207	-9.413469
6	8546.525	3.648670	2.74e-07	-9.435797	-9.356633	-9.406579
7	8556.014	18.82044	2.72e-07	-9.441876	-9.350532	-9.408163
8	8558.196	4.324495	2.73e-07	-9.439863	-9.336341	-9.401655
9	8568.167	19.73200	2.71e-07	-9.446476	-9.330774	-9.403773
10	8575.119	13.74117*	2.70e-07*	-9.449744*	-9.321863	-9.402546
11	8576.533	2.793091	2.71e-07	-9.446881	-9.306821	-9.395188
12	8578.797	4.464575	2.71e-07	-9.444958	-9.292719	-9.388770

CORRIANDER

0	476.7174	NA	0.001978	-0.549760	-0.543443	-0.547423
1	8966.812	16950.69	1.07e-07	-10.37732	-10.35837*	-10.37031
2	9030.354	126.7148*	9.96e-08	-10.44627	-10.41469	-10.43459*
3	9034.378	8.016330	9.96e-08*	-10.44630*	-10.40208	-10.42994
4	9037.952	7.110286	9.97e-08	-10.44580	-10.38896	-10.42478
5	9042.222	8.486492	9.96e-08	-10.44612	-10.37664	-10.42042
6	9045.426	6.360091	9.97e-08	-10.44520	-10.36308	-10.41482
7	9048.367	5.830797	9.98e-08	-10.44397	-10.34922	-10.40892
8	9049.707	2.652465	1.00e-07	-10.44089	-10.33351	-10.40117
9	9052.957	6.429322	1.00e-07	-10.44002	-10.32001	-10.39563
10	9054.306	2.665002	1.01e-07	-10.43695	-10.30431	-10.38788
11	9054.779	0.933293	1.01e-07	-10.43287	-10.28759	-10.37913
12	9054.841	0.121049	1.01e-07	-10.42830	-10.27040	-10.36989

COTTON SEED OIL CAKE

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-272.2877	NA	0.004241	0.212791	0.217333	0.214437
1	12720.69	25955.71	1.78e-07	-9.863994	-9.850368*	-9.859055
2	12738.02	34.59146*	1.76e-07*	-9.874335*	-9.851624	-9.866103*
3	12741.38	6.709578	1.77e-07	-9.873841	-9.842047	-9.862316
4	12741.48	0.198518	1.77e-07	-9.870816	-9.829937	-9.855998
5	12742.28	1.596524	1.78e-07	-9.868334	-9.818371	-9.850224

6	12743.17	1.767978	1.78e-07	-9.865920	-9.806873	-9.844517
7	12744.53	2.696513	1.78e-07	-9.863869	-9.795738	-9.839173
8	12746.31	3.544754	1.79e-07	-9.862150	-9.784935	-9.834161
9	12748.75	4.844348	1.79e-07	-9.860940	-9.774640	-9.829658
10	12749.36	1.212434	1.79e-07	-9.858311	-9.762927	-9.823736
11	12750.69	2.639905	1.80e-07	-9.856241	-9.751773	-9.818373
12	12751.98	2.550438	1.80e-07	-9.854137	-9.740584	-9.812976
			COTTON			
0	1668.078	NA	1.49e-05	-5.435819	-5.421403	-5.430212
1	3478.834	3603.788	4.11e-08	-11.33062	-11.28737*	-11.31380
2	3495.864	33.78225*	3.94e-08*	-11.37313*	-11.30105	-11.34510*
3	3497.925	4.073652	3.97e-08	-11.36680	-11.26589	-11.32756
4	3500.002	4.093956	3.99e-08	-11.36053	-11.23079	-11.31007
5	3501.657	3.251310	4.02e-08	-11.35288	-11.19431	-11.29121
6	3502.642	1.927242	4.06e-08	-11.34304	-11.15564	-11.27016
7	3503.706	2.075310	4.10e-08	-11.33346	-11.11723	-11.24937
8	3504.024	0.619382	4.15e-08	-11.32145	-11.07638	-11.22614
9	3504.674	1.259178	4.20e-08	-11.31052	-11.03662	-11.20400
10	3505.009	0.647250	4.25e-08	-11.29856	-10.99583	-11.18083
11	3505.721	1.370246	4.29e-08	-11.28783	-10.95628	-11.15889
12	3506.372	1.248878	4.34e-08	-11.27691	-10.91652	-11.13675
			CRUDE PALM OIL			
0	3503.500	NA	0.000372	-2.219651	-2.215812	-2.218274
1	20069.14	33099.77	1.03e-08	-12.71831	-12.70679*	-12.71418
2	20145.23	151.9387	9.81e-09	-12.76401	-12.74481	-12.75712
3	20170.41	50.25635	9.68e-09*	-12.77744*	-12.75056	-12.76780*
4	20171.39	1.945621	9.70e-09	-12.77552	-12.74097	-12.76313
5	20177.93	13.03021*	9.68e-09	-12.77713	-12.73490	-12.76198
6	20180.23	4.583702	9.69e-09	-12.77605	-12.72614	-12.75815
7	20181.83	3.184373	9.71e-09	-12.77453	-12.71694	-12.75387
8	20184.81	5.926653	9.71e-09	-12.77389	-12.70862	-12.75047
9	20188.49	7.327291	9.72e-09	-12.77369	-12.70074	-12.74751
10	20192.76	8.485118	9.71e-09	-12.77386	-12.69323	-12.74493
11	20192.94	0.361388	9.74e-09	-12.77144	-12.68313	-12.73976
12	20193.48	1.061002	9.76e-09	-12.76924	-12.67326	-12.73480
			GAUR GUM			
0	2994.514	NA	0.000252	-2.611269	-2.606263	-2.609444
1	12247.02	18480.79	7.87e-08	-10.68152	-10.66650*	-10.67604
2	12437.42	379.9704	6.69e-08	-10.84417	-10.81914	-10.83504
3	12451.81	28.68683	6.63e-08	-10.85323	-10.81819	-10.84046*
4	12454.02	4.411322	6.64e-08	-10.85168	-10.80662	-10.83525
5	12455.86	3.669042	6.65e-08	-10.84979	-10.79473	-10.82971
6	12462.88	13.95289	6.64e-08	-10.85243	-10.78734	-10.82869
7	12466.71	7.609141	6.64e-08	-10.85228	-10.77718	-10.82489
8	12469.42	5.379180	6.64e-08	-10.85115	-10.76604	-10.82012
9	12476.38	13.81430*	6.63e-08*	-10.85374*	-10.75862	-10.81905
10	12476.88	0.983023	6.65e-08	-10.85068	-10.74555	-10.81234
11	12479.47	5.132896	6.66e-08	-10.84945	-10.73431	-10.80747
12	12483.07	7.109375	6.66e-08	-10.84910	-10.72394	-10.80346

GAUR SEED						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	3157.111	NA	0.000237	-2.670429	-2.665547	-2.668651
1	12698.02	19057.59	7.41e-08	-10.74229	-10.72765*	-10.73696
2	12878.72	360.6346	6.38e-08	-10.89185	-10.86744	-10.88296
3	12898.08	38.59960	6.30e-08	-10.90485	-10.87067	-10.89240*
4	12901.60	7.028021	6.30e-08	-10.90445	-10.86051	-10.88845
5	12903.48	3.732881	6.31e-08	-10.90265	-10.84895	-10.88310
6	12909.65	12.27635	6.30e-08	-10.90449	-10.84102	-10.88138
7	12915.34	11.30938	6.29e-08	-10.90592	-10.83269	-10.87926
8	12918.63	6.531353	6.29e-08	-10.90532	-10.82233	-10.87510
9	12927.34	17.27470*	6.27e-08*	-10.90930*	-10.81655	-10.87553
10	12929.14	3.573959	6.28e-08	-10.90744	-10.80493	-10.87012
11	12930.72	3.120985	6.29e-08	-10.90539	-10.79311	-10.86451
12	12932.79	4.108664	6.30e-08	-10.90376	-10.78172	-10.85933
GAUR						
0	2341.421	NA	0.000336	-2.323159	-2.317590	-2.321115
1	11712.76	18714.76	3.06e-08	-11.62538	-11.60867	-11.61925
2	11780.68	135.5105*	2.88e-08*	-11.68886*	-11.66102*	-11.67864*
3	11781.76	2.156852	2.88e-08	-11.68596	-11.64698	-11.67165
4	11785.18	6.799266	2.89e-08	-11.68538	-11.63526	-11.66699
5	11787.33	4.276888	2.89e-08	-11.68355	-11.62229	-11.66106
6	11789.42	4.157249	2.90e-08	-11.68165	-11.60925	-11.65508
7	11792.02	5.160291	2.90e-08	-11.68026	-11.59673	-11.64960
8	11792.30	0.544518	2.91e-08	-11.67656	-11.58189	-11.64181
9	11794.23	3.830465	2.92e-08	-11.67451	-11.56870	-11.63567
10	11794.88	1.282471	2.93e-08	-11.67118	-11.55423	-11.62825
11	11796.35	2.919872	2.93e-08	-11.66867	-11.54059	-11.62166
12	11801.08	9.332955	2.93e-08	-11.66939	-11.53017	-11.61829
JEERA						
0	4439.939	NA	0.000143	-3.180179	-3.175926	-3.178644
1	16133.06	23361.10	3.28e-08	-11.55647	-11.54372	-11.55187
2	16342.12	417.3665	2.83e-08	-11.70341	-11.68215*	-11.69574
3	16368.86	53.35874	2.79e-08	-11.71971	-11.68995	-11.70897
4	16381.60	25.40350	2.77e-08	-11.72598	-11.68771	-11.71216*
5	16389.60	15.92488*	2.76e-08*	-11.72884*	-11.68207	-11.71195
6	16392.34	5.462082	2.76e-08	-11.72794	-11.67266	-11.70798
7	16394.42	4.122632	2.77e-08	-11.72656	-11.66278	-11.70353
8	16395.75	2.657347	2.77e-08	-11.72465	-11.65236	-11.69855
9	16397.69	3.855717	2.78e-08	-11.72318	-11.64238	-11.69401
10	16399.29	3.161439	2.78e-08	-11.72145	-11.63215	-11.68921
11	16402.00	5.386540	2.79e-08	-11.72053	-11.62273	-11.68522
12	16404.31	4.584982	2.79e-08	-11.71932	-11.61301	-11.68094
KAPAS						
0	746.2518	NA	0.000212	-2.782250	-2.766241	-2.775986
1	2224.668	2940.251	8.57e-07	-8.294084	-8.246059*	-8.275294
2	2227.593	5.796470	8.60e-07	-8.290068	-8.210025	-8.258751
3	2239.815	24.12325*	8.34e-07*	-8.320803*	-8.208743	-8.276959*

4	2240.728	1.796884	8.44e-07	-8.309265	-8.165189	-8.252895
5	2243.333	5.101513	8.49e-07	-8.304048	-8.127955	-8.235150
6	2245.000	3.253883	8.56e-07	-8.295328	-8.087218	-8.213904
7	2245.700	1.359761	8.67e-07	-8.282990	-8.042863	-8.189039
8	2245.864	0.317736	8.79e-07	-8.268650	-7.996506	-8.162172
9	2245.912	0.093328	8.92e-07	-8.253877	-7.949716	-8.134873
10	2248.027	4.063660	8.99e-07	-8.246830	-7.910652	-8.115299
11	2248.393	0.700532	9.11e-07	-8.233245	-7.865050	-8.089187
12	2249.841	2.759874	9.20e-07	-8.223703	-7.823491	-8.067118
			MAIZE			
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-767.6022	NA	0.006762	0.679261	0.684314	0.681104
1	11170.06	23843.71*	1.80e-07*	-9.853535*	-9.838374*	-9.848003*
2	11170.29	0.466905	1.81e-07	-9.850211	-9.824943	-9.840992
3	11170.79	1.004358	1.81e-07	-9.847125	-9.811750	-9.834218
4	11173.39	5.175922	1.82e-07	-9.845888	-9.800405	-9.829293
5	11175.69	4.569270	1.82e-07	-9.844384	-9.788794	-9.824101
6	11176.61	1.834869	1.82e-07	-9.841668	-9.775971	-9.817697
7	11177.05	0.882145	1.83e-07	-9.838529	-9.762725	-9.810871
8	11178.35	2.576365	1.83e-07	-9.836144	-9.750233	-9.804798
9	11178.82	0.923576	1.84e-07	-9.833025	-9.737006	-9.797991
10	11180.73	3.788439	1.84e-07	-9.831182	-9.725056	-9.792460
11	11184.50	7.461757	1.84e-07	-9.830978	-9.714745	-9.788569
12	11184.83	0.651356	1.85e-07	-9.827738	-9.701398	-9.781641
			MENTA OIL			
0	1936.125	NA	0.000267	-2.551616	-2.544592	-2.549001
1	7932.639	11969.30	9.85e-08	-10.45731	-10.43624	-10.44946
2	7987.465	109.2901	9.21e-08	-10.52436	-10.48924*	-10.51128*
3	7993.485	11.98349	9.19e-08*	-10.52702*	-10.47786	-10.50872
4	7996.326	5.648943	9.20e-08	-10.52550	-10.46228	-10.50196
5	7999.317	5.938215	9.21e-08	-10.52416	-10.44691	-10.49540
6	8003.244	7.787428	9.22e-08	-10.52407	-10.43276	-10.49007
7	8003.717	0.935798	9.26e-08	-10.51942	-10.41406	-10.48019
8	8010.289	12.99562*	9.23e-08	-10.52281	-10.40341	-10.47835
9	8011.836	3.055724	9.26e-08	-10.51957	-10.38613	-10.46988
10	8013.969	4.207187	9.28e-08	-10.51711	-10.36962	-10.46219
11	8017.411	6.780112	9.29e-08	-10.51637	-10.35483	-10.45623
12	8021.639	8.315378	9.28e-08	-10.51667	-10.34109	-10.45130
			MUSTARD OIL			
0	2472.294	NA	5.41e-05	-4.148268	-4.139733	-4.145052
1	7808.427	10645.38	7.00e-09	-13.10231	-13.07671	-13.09266
2	7934.096	250.2840	5.70e-09*	-13.30663*	-13.26395*	-13.29055*
3	7935.223	2.240855	5.73e-09	-13.30180	-13.24206	-13.27929
4	7939.679	8.843939	5.73e-09	-13.30257	-13.22575	-13.27362
5	7944.480	9.513707	5.72e-09	-13.30391	-13.21003	-13.26853
6	7945.775	2.560646	5.74e-09	-13.29937	-13.18842	-13.25756
7	7950.760	9.844217	5.73e-09	-13.30102	-13.17300	-13.25278
8	7956.586	11.48623*	5.72e-09	-13.30409	-13.15900	-13.24941
9	7958.492	3.751084	5.74e-09	-13.30057	-13.13841	-13.23947

10	7962.679	8.227100	5.74e-09	-13.30089	-13.12166	-13.23335
11	7966.968	8.412773	5.73e-09	-13.30137	-13.10507	-13.22740
12	7968.114	2.242189	5.76e-09	-13.29658	-13.08321	-13.21617
			PEAS			
0	1583.904	NA	0.000288	-2.477532	-2.469463	-2.474502
1	7850.061	12502.87	1.58e-08	-12.28514	-12.26093*	-12.27605
2	7900.541	100.5630	1.47e-08	-12.35793	-12.31759	-12.34278
3	7919.945	38.59584	1.44e-08	-12.38206	-12.32557	-12.36085*
4	7924.865	9.770626	1.44e-08	-12.38350	-12.31088	-12.35623
5	7928.114	6.443128	1.44e-08	-12.38232	-12.29356	-12.34899
6	7933.227	10.12117	1.43e-08*	-12.38407*	-12.27917	-12.34467
7	7935.543	4.577726	1.44e-08	-12.38143	-12.26039	-12.33598
8	7937.603	4.064194	1.44e-08	-12.37839	-12.24121	-12.32688
9	7938.145	1.067921	1.45e-08	-12.37298	-12.21966	-12.31540
10	7944.038	11.59262*	1.45e-08	-12.37594	-12.20648	-12.31230
11	7945.612	3.091465	1.45e-08	-12.37214	-12.18655	-12.30244
12	7948.730	6.113505	1.45e-08	-12.37076	-12.16903	-12.29500
			PEPPER			
Lag	LogL	LR	FPE	AIC	SC	HQ
0	1919.261	NA	0.000699	-1.590428	-1.585627	-1.588682
1	14279.38	24689.48	2.47e-08	-11.84022	-11.82581	-11.83498
2	14625.30	690.4087	1.86e-08	-12.12385	-12.09985*	-12.11512
3	14645.10	39.47515	1.84e-08	-12.13696	-12.10335	-12.12473
4	14656.11	21.93482	1.83e-08	-12.14277	-12.09956	-12.12705
5	14667.00	21.69461	1.82e-08	-12.14849	-12.09568	-12.12928
6	14676.46	18.80920*	1.81e-08*	-12.15302*	-12.09060	-12.13031*
7	14677.29	1.648966	1.81e-08	-12.15039	-12.07837	-12.12419
8	14680.39	6.152312	1.81e-08	-12.14964	-12.06802	-12.11995
9	14681.95	3.093432	1.82e-08	-12.14761	-12.05639	-12.11443
10	14683.94	3.947637	1.82e-08	-12.14595	-12.04512	-12.10927
11	14684.66	1.421552	1.83e-08	-12.14322	-12.03280	-12.10306
12	14685.61	1.890403	1.83e-08	-12.14070	-12.02067	-12.09704
			POTATO			
0	-2.040573	NA	0.003458	0.008680	0.019069	0.012642
1	3431.232	6844.419*	2.18e-06*	-7.358179*	-7.327010*	-7.346291*
2	3433.099	3.713623	2.19e-06	-7.353596	-7.301649	-7.333784
3	3434.586	2.952514	2.21e-06	-7.348198	-7.275473	-7.320462
4	3434.734	0.291407	2.23e-06	-7.339922	-7.246417	-7.304260
5	3435.519	1.551719	2.24e-06	-7.333015	-7.218732	-7.289429
6	3436.303	1.546914	2.26e-06	-7.326108	-7.191045	-7.274597
7	3437.329	2.019790	2.27e-06	-7.319720	-7.163879	-7.260284
8	3437.815	0.952971	2.29e-06	-7.312169	-7.135550	-7.244809
9	3438.126	0.610027	2.31e-06	-7.304245	-7.106847	-7.228960
10	3439.417	2.522891	2.32e-06	-7.298425	-7.080248	-7.215215
11	3440.476	2.065678	2.33e-06	-7.292107	-7.053151	-7.200972
12	3441.270	1.545807	2.35e-06	-7.285220	-7.025486	-7.186161
			RUBBER			
0	722.7516	NA	0.001453	-0.858038	-0.851577	-0.855645
1	8458.091	15443.05	1.46e-07	-10.06201	-10.04263*	-10.05483

2	8471.517	26.77171*	1.45e-07*	-10.07323*	-10.04093	-10.06127*
3	8474.252	5.447305	1.45e-07	-10.07173	-10.02651	-10.05498
4	8476.474	4.420380	1.45e-07	-10.06961	-10.01147	-10.04808
5	8476.714	0.477096	1.46e-07	-10.06514	-9.994074	-10.03881
6	8477.429	1.418200	1.46e-07	-10.06122	-9.977243	-10.03012
7	8479.779	4.658257	1.47e-07	-10.05926	-9.962358	-10.02337
8	8481.643	3.689552	1.47e-07	-10.05672	-9.946895	-10.01604
9	8483.627	3.924301	1.47e-07	-10.05432	-9.931575	-10.00885
10	8484.251	1.231116	1.48e-07	-10.05030	-9.914635	-10.00005
11	8486.386	4.211706	1.48e-07	-10.04808	-9.899494	-9.993039
12	8487.074	1.356044	1.49e-07	-10.04414	-9.882631	-9.984311
SOYA BEAN						
0	2707.525	NA	0.000625	-1.702659	-1.698843	-1.701291
1	18514.73	31584.56	2.99e-08	-11.64803	-11.63659	-11.64393
2	18657.54	285.1819	2.74e-08	-11.73539	-11.71631*	-11.72855*
3	18659.59	4.086333	2.75e-08	-11.73417	-11.70745	-11.72458
4	18660.85	2.512239	2.75e-08	-11.73244	-11.69809	-11.72012
5	18662.07	2.436408	2.76e-08	-11.73069	-11.68871	-11.71564
6	18668.72	13.24217	2.75e-08	-11.73236	-11.68275	-11.71457
7	18676.91	16.30298	2.75e-08	-11.73500	-11.67775	-11.71447
8	18685.25	16.59817	2.74e-08	-11.73773	-11.67285	-11.71446
9	18695.26	19.88608*	2.73e-08*	-11.74151*	-11.66900	-11.71550
10	18699.23	7.897289	2.73e-08	-11.74149	-11.66135	-11.71275
11	18700.40	2.324173	2.73e-08	-11.73971	-11.65194	-11.70823
12	18703.09	5.324588	2.73e-08	-11.73888	-11.64348	-11.70467
SOYA OIL						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	5405.424	NA	4.78e-05	-4.273170	-4.268555	-4.271496
1	16330.22	21823.67	8.48e-09	-12.90962	-12.89578	-12.90460
2	16449.30	237.6857	7.74e-09*	-13.00063*	-12.97756*	-12.99226*
3	16452.41	6.214657	7.75e-09	-12.99993	-12.96763	-12.98821
4	16455.36	5.862766	7.76e-09	-12.99910	-12.95756	-12.98403
5	16460.40	10.03956	7.75e-09	-12.99992	-12.94916	-12.98150
6	16464.12	7.399882	7.75e-09	-12.99970	-12.93970	-12.97793
7	16464.78	1.318968	7.77e-09	-12.99706	-12.92783	-12.97194
8	16468.60	7.584946	7.77e-09	-12.99691	-12.91846	-12.96845
9	16468.72	0.249609	7.80e-09	-12.99385	-12.90617	-12.96204
10	16473.57	9.600927*	7.79e-09	-12.99452	-12.89760	-12.95935
11	16476.21	5.243442	7.80e-09	-12.99344	-12.88730	-12.95493
12	16476.70	0.972630	7.82e-09	-12.99067	-12.87530	-12.94881
SUGAR						
0	2746.552	NA	8.51e-05	-3.696366	-3.689224	-3.693704
1	9251.161	12982.94	1.34e-08	-12.45140	-12.42997	-12.44341
2	9309.271	115.8291	1.25e-08	-12.52427	-12.48856*	-12.51096*
3	9313.708	8.831885	1.25e-08	-12.52486	-12.47486	-12.50622
4	9318.030	8.591580	1.25e-08*	-12.52529*	-12.46101	-12.50133
5	9319.900	3.711325	1.25e-08	-12.52242	-12.44386	-12.49314
6	9320.835	1.854649	1.25e-08	-12.51830	-12.42545	-12.48369
7	9322.230	2.761410	1.26e-08	-12.51479	-12.40765	-12.47486

8	9323.594	2.696774	1.26e-08	-12.51124	-12.38982	-12.46598
9	9325.382	3.530444	1.27e-08	-12.50826	-12.37255	-12.45768
10	9329.179	7.486130	1.27e-08	-12.50799	-12.35800	-12.45208
11	9336.792	14.99083*	1.26e-08	-12.51285	-12.34858	-12.45162
12	9339.678	5.673726	1.26e-08	-12.51135	-12.33279	-12.44480
			TURMERIC			
0	-12.04787	NA	0.003472	0.012788	0.017972	0.014683
1	11073.83	22141.47	1.44e-07	-10.07540	-10.05985	-10.06972
2	11188.51	228.8432	1.30e-07	-10.17616	-10.15024*	-10.16669*
3	11190.94	4.844467	1.31e-07	-10.17473	-10.13844	-10.16147
4	11195.78	9.642248	1.31e-07	-10.17549	-10.12884	-10.15844
5	11196.31	1.049602	1.31e-07	-10.17233	-10.11531	-10.15149
6	11199.86	7.052315	1.31e-07	-10.17192	-10.10453	-10.14729
7	11207.91	16.00702	1.31e-07	-10.17562	-10.09785	-10.14720
8	11212.70	9.507273*	1.30e-07*	-10.17634*	-10.08820	-10.14413
9	11216.16	6.854865	1.31e-07	-10.17584	-10.07734	-10.13985
10	11216.84	1.338658	1.31e-07	-10.17282	-10.06395	-10.13303
11	11217.38	1.078589	1.31e-07	-10.16967	-10.05043	-10.12610
12	11218.85	2.908755	1.32e-07	-10.16737	-10.03776	-10.12001
			WHEAT			
0	3533.108	NA	0.000118	-3.369378	-3.363989	-3.367404
1	13178.07	19262.31	1.19e-08	-12.56876	-12.55260	-12.56284
2	13222.51	88.67145	1.15e-08	-12.60735	-12.58041*	-12.59748
3	13231.23	17.39492	1.14e-08	-12.61186	-12.57414	-12.59805*
4	13237.01	11.50458	1.14e-08	-12.61356	-12.56506	-12.59579
5	13239.49	4.931378	1.14e-08	-12.61211	-12.55283	-12.59039
6	13240.39	1.782546	1.15e-08	-12.60915	-12.53909	-12.58348
7	13259.88	38.71308	1.13e-08	-12.62393	-12.54310	-12.59432
8	13267.64	15.39399	1.12e-08	-12.62752	-12.53591	-12.59396
9	13272.81	10.23726	1.12e-08	-12.62863	-12.52624	-12.59113
10	13279.56	13.36930*	1.12e-08*	-12.63126*	-12.51809	-12.58980
11	13281.87	4.577826	1.12e-08	-12.62965	-12.50570	-12.58425
12	13284.42	5.022153	1.12e-08	-12.62826	-12.49353	-12.57891
			BULLION			
			GOLD			
Lag	LogL	LR	FPE	AIC	SC	HQ
0	4378.669	NA	6.95e-05	-3.899037	-3.893945	-3.897178
1	9701.196	10630.83	6.08e-07	-8.637146	-8.621868*	-8.631569
2	9848.078	293.1096	5.35e-07	-8.764435	-8.738971	-8.755140
3	9865.538	34.81132	5.29e-07	-8.776426	-8.740777	-8.763413
4	9892.694	54.09427	5.18e-07	-8.797055	-8.751221	-8.780324
5	9915.657	45.70064	5.10e-07	-8.813948	-8.757929	-8.793499
6	9927.921	24.38723	5.06e-07	-8.821311	-8.755107	-8.797144
7	9939.610	23.22200	5.02e-07	-8.828161	-8.751772	-8.800276
8	9949.978	20.57875	5.00e-07	-8.833834	-8.747259	-8.802231
9	9960.877	21.61319	4.96e-07	-8.839980	-8.743220	-8.804659
10	9972.122	22.27878	4.93e-07	-8.846434	-8.739489	-8.807395*
11	9975.678	7.039358	4.93e-07	-8.846038	-8.728908	-8.803282
12	9980.979	10.48365*	4.93e-07*	-8.847197*	-8.719882	-8.800722

PLATINUM						
0	1525.120	NA	0.000195	-2.865700	-2.856351	-2.862158
1	4125.214	5185.512	1.48e-06	-7.750167	-7.722121*	-7.739539
2	4133.305	16.10599	1.47e-06	-7.757864	-7.711121	-7.740151
3	4138.629	10.57911	1.46e-06	-7.760356	-7.694915	-7.735558
4	4151.511	25.54513	1.44e-06	-7.777067	-7.692928	-7.745183*
5	4152.786	2.523951	1.44e-06	-7.771940	-7.669104	-7.732971
6	4158.314	10.92109	1.44e-06	-7.774815	-7.653282	-7.728761
7	4160.817	4.933934	1.44e-06	-7.771997	-7.631767	-7.718858
8	4177.268	32.37576	1.41e-06	-7.795424	-7.636495	-7.735199
9	4177.981	1.401527	1.42e-06	-7.789240	-7.611614	-7.721930
10	4185.846	15.41829*	1.41e-06*	-7.796511*	-7.600188	-7.722116
11	4188.728	5.639068	1.41e-06	-7.794407	-7.579387	-7.712927
12	4192.506	7.378226	1.41e-06	-7.793990	-7.560271	-7.705424
SILVER						
0	3773.972	NA	0.000123	-3.326254	-3.321204	-3.324412
1	8060.492	8561.701	2.82e-06	-7.102727	-7.087577*	-7.097200
2	8108.742	96.28587	2.71e-06	-7.141748	-7.116498	-7.132535
3	8153.909	90.05588	2.62e-06	-7.178050	-7.142701	-7.165153
4	8184.731	61.39941	2.56e-06	-7.201703	-7.156253	-7.185121
5	8200.332	31.05053	2.53e-06	-7.211933	-7.156383	-7.191666
6	8208.250	15.74451	2.52e-06	-7.215388	-7.149738	-7.191436
7	8216.668	16.72605	2.51e-06	-7.219284	-7.143535	-7.191647
8	8232.602	31.62762	2.48e-06	-7.229807	-7.143958	-7.198486
9	8244.085	22.77435	2.47e-06	-7.236406	-7.140457	-7.201400
10	8253.459	18.57419	2.46e-06	-7.241145	-7.135096	-7.202454*
11	8261.244	15.41293	2.45e-06	-7.244483	-7.128334	-7.202107
12	8266.728	10.84718*	2.44e-06*	-7.245792*	-7.119543	-7.199731
ENERGY						
ATF						
0	1032.123	NA	0.000392	-2.168680	-2.158456	-2.164785
1	2406.592	2740.256	2.19e-05	-5.053877	-5.023205*	-5.042191
2	2416.885	20.47838	2.16e-05	-5.067126	-5.016006	-5.047649
3	2433.190	32.36975	2.10e-05	-5.093032	-5.021463	-5.065763*
4	2438.795	11.10343	2.10e-05	-5.096410	-5.004393	-5.061350
5	2445.403	13.06338	2.09e-05	-5.101901	-4.989436	-5.059050
6	2450.772	10.59014	2.08e-05	-5.104782	-4.971869	-5.054140
7	2453.529	5.427025	2.09e-05	-5.102166	-4.948804	-5.043733
8	2462.345	17.31633*	2.06e-05*	-5.112304*	-4.938494	-5.046080
9	2463.743	2.740975	2.08e-05	-5.106828	-4.912569	-5.032812
10	2464.154	0.804228	2.09e-05	-5.099272	-4.884565	-5.017466
11	2468.025	7.553095	2.09e-05	-5.098999	-4.863844	-5.009402
12	2469.558	2.985575	2.10e-05	-5.093806	-4.838202	-4.996417
BRENT CRUDE OIL						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	3080.779	NA	0.000100	-3.532735	-3.526466	-3.530417
1	5666.412	5162.366	5.18e-06	-6.495023	-6.476216*	-6.488069
2	5731.451	129.7039	4.83e-06	-6.565061	-6.533717	-6.553472
3	5760.180	57.22808	4.69e-06	-6.593437	-6.549554	-6.577212

4	5770.840	21.20971	4.66e-06	-6.601079	-6.544658	-6.580218
5	5796.541	51.07701	4.54e-06	-6.625979	-6.557021	-6.600483*
6	5798.660	4.207669	4.55e-06	-6.623821	-6.542326	-6.593689
7	5807.562	17.64991	4.53e-06	-6.629446	-6.535412	-6.594678
8	5811.893	8.577885	4.53e-06	-6.629826	-6.523254	-6.590422
9	5815.740	7.609022	4.53e-06	-6.629650	-6.510540	-6.585610
10	5820.654	9.709661	4.52e-06	-6.630698	-6.499051	-6.582023
11	5829.332	17.12732*	4.50e-06*	-6.636066*	-6.491881	-6.582756
12	5831.886	5.034165	4.51e-06	-6.634407	-6.477684	-6.576460
CRUDE OIL						
0	3618.270	NA	0.000138	-3.213034	-3.207953	-3.211180
1	6483.294	5722.411	1.09e-05	-5.755037	-5.739793*	-5.749473
2	6597.751	228.4046	9.84e-06	-5.853177	-5.827770	-5.843904
3	6623.987	52.30913	9.65e-06	-5.872934	-5.837364	-5.859951
4	6657.146	66.05260	9.40e-06	-5.898841	-5.853108	-5.882149
5	6689.899	65.18693	9.16e-06	-5.924388	-5.868493	-5.903987
6	6698.739	17.57871	9.13e-06	-5.928689	-5.862631	-5.904579
7	6710.166	22.70061	9.07e-06	-5.935287	-5.859066	-5.907468
8	6713.870	7.351692	9.07e-06	-5.935024	-5.848640	-5.903495
9	6729.741	31.47521	8.97e-06	-5.945572	-5.849025	-5.910334*
10	6734.365	9.161980	8.97e-06	-5.946127	-5.839417	-5.907179
11	6742.531	16.16438*	8.93e-06*	-5.949828*	-5.832955	-5.907171
12	6744.427	3.750015	8.95e-06	-5.947958	-5.820923	-5.901592
FURNACE OIL						
0	767.8879	NA	0.000321	-2.367505	-2.353680	-2.362142
1	1250.554	960.8562	7.32e-05	-3.847153	-3.805678*	-3.831063*
2	1253.673	6.189834	7.34e-05	-3.844430	-3.775305	-3.817612
3	1257.921	8.404625	7.33e-05	-3.845197	-3.748423	-3.807653
4	1259.582	3.274667	7.38e-05	-3.837965	-3.713541	-3.789694
5	1267.557	15.68016	7.29e-05*	-3.850255*	-3.698181	-3.791257
6	1268.475	1.798586	7.36e-05	-3.840727	-3.661003	-3.771002
7	1274.675	12.11214*	7.31e-05	-3.847527	-3.640154	-3.767075
8	1278.991	8.405699	7.31e-05	-3.848504	-3.613482	-3.757326
9	1279.111	0.233028	7.39e-05	-3.836511	-3.573838	-3.734605
10	1279.595	0.936059	7.48e-05	-3.825641	-3.535319	-3.713009
11	1283.536	7.601215	7.48e-05	-3.825458	-3.507486	-3.702098
12	1284.812	2.453590	7.54e-05	-3.817038	-3.471416	-3.682951
GASOLINE						
0	1896.008	NA	3.42e-05	-4.608292	-4.596828	-4.603894
1	3064.513	2328.480	2.01e-06	-7.441637	-7.407244*	-7.428442
2	3098.156	66.87779	1.87e-06	-7.513762	-7.456442	-7.491770
3	3135.382	73.81705	1.72e-06	-7.594603	-7.514354	-7.563814
4	3159.812	48.32608	1.64e-06	-7.644312	-7.541135	-7.604727
5	3177.383	34.67097	1.59e-06	-7.677331	-7.551226	-7.628949*
6	3182.544	10.15869*	1.58e-06*	-7.680155*	-7.531122	-7.622977
7	3185.626	6.051819	1.59e-06	-7.677922	-7.505961	-7.611947
8	3185.682	0.108799	1.60e-06	-7.668325	-7.473435	-7.593553
9	3187.437	3.428892	1.61e-06	-7.662863	-7.445045	-7.579294
10	3192.036	8.964823	1.61e-06	-7.664322	-7.423576	-7.571957

11	3192.700	1.290747	1.62e-06	-7.656205	-7.392531	-7.555044
12	3195.666	5.750302	1.63e-06	-7.653688	-7.367086	-7.543730
			HEATING OIL			
0	2025.486	NA	4.71e-05	-4.287046	-4.276770	-4.283130
1	3439.431	2818.904	2.38e-06	-7.274219	-7.243392*	-7.262470
2	3476.159	73.06692	2.22e-06	-7.343558	-7.292180	-7.323976
3	3504.102	55.47061	2.11e-06	-7.394284	-7.322354	-7.366869
4	3511.940	15.52604	2.09e-06	-7.402415	-7.309933	-7.367167
5	3519.787	15.51123	2.07e-06	-7.410565	-7.297532	-7.367485*
6	3522.338	5.031843	2.08e-06	-7.407495	-7.273911	-7.356582
7	3527.639	10.43476	2.07e-06	-7.410253	-7.256118	-7.351507
8	3541.222	26.67681	2.03e-06	-7.430556	-7.255869	-7.363977
9	3548.259	13.78926	2.02e-06	-7.436989	-7.241751	-7.362577
10	3550.984	5.328688	2.02e-06	-7.434287	-7.218498	-7.352043
11	3558.253	14.18474	2.01e-06	-7.441214	-7.204873	-7.351137
12	3563.609	10.42755*	2.01e-06*	-7.444086*	-7.187194	-7.346177
			NATURAL GAS			
0	2317.857	NA	0.000437	-2.060371	-2.055284	-2.058515
1	5184.243	5725.120	3.42e-05	-4.606978	-4.591717*	-4.601407
2	5279.674	190.4385	3.15e-05	-4.688322	-4.662887	-4.679038
3	5327.378	95.11078	3.03e-05	-4.727205	-4.691596	-4.714207
4	5341.549	28.22713	3.01e-05	-4.736253	-4.690470	-4.719542
5	5361.117	38.94548	2.97e-05	-4.750104	-4.694147	-4.729679
6	5378.329	34.22403	2.93e-05	-4.761858	-4.695727	-4.737720
7	5397.829	38.74063	2.89e-05	-4.775649	-4.699343	-4.747796
8	5414.242	32.57708	2.86e-05	-4.786692	-4.700213	-4.755126*
9	5417.670	6.798026	2.86e-05	-4.786183	-4.689530	-4.750904
10	5424.376	13.28696	2.85e-05	-4.788591	-4.681763	-4.749597
11	5432.777	16.63065	2.84e-05	-4.792506	-4.675505	-4.749800
12	5444.951	24.07768*	2.82e-05*	-4.799779*	-4.672604	-4.753358
			METAL			
			ALUMINIUM			
0	8650.968	NA	1.81e-06	-7.543802	-7.538797	-7.541977
1	13286.96	9259.854	3.19e-08	-11.58392	-11.56890*	-11.57844
2	13521.19	467.4368	2.61e-08	-11.78473	-11.75971	-11.77560
3	13577.88	113.0419	2.49e-08	-11.83069	-11.79566	-11.81791
4	13596.87	37.81425	2.46e-08	-11.84376	-11.79872	-11.82733
5	13617.72	41.50846	2.43e-08	-11.85846	-11.80341	-11.83838
6	13725.61	214.5634	2.22e-08	-11.94907	-11.88402	-11.92535
7	13767.06	82.34164	2.15e-08	-11.98173	-11.90666	-11.95436
8	13772.97	11.74532	2.14e-08	-11.98340	-11.89833	-11.95238
9	13777.79	9.563132	2.14e-08	-11.98412	-11.88903	-11.94945
10	13785.98	16.22575	2.13e-08	-11.98777	-11.88268	-11.94945
11	13790.93	9.803579	2.13e-08	-11.98860	-11.87350	-11.94663
12	13824.24	65.89622*	2.08e-08*	-12.01417*	-11.88906	-11.96855*
			COPPER			
0	5582.866	NA	2.41e-05	-4.958566	-4.953484	-4.956711
1	12717.21	14249.67	4.27e-08	-11.29383	-11.27859*	-11.28827
2	13271.35	1105.827	2.62e-08	-11.78263	-11.75723	-11.77336

3	13359.34	175.4334	2.43e-08	-11.85726	-11.82169	-11.84427
4	13396.58	74.17188	2.36e-08	-11.88679	-11.84105	-11.87009
5	13427.39	61.31353	2.30e-08	-11.91060	-11.85471	-11.89020
6	13435.83	16.78866	2.29e-08	-11.91455	-11.84849	-11.89044
7	13446.17	20.54521	2.28e-08	-11.92019	-11.84397	-11.89237
8	13462.46	32.32635	2.26e-08	-11.93110	-11.84472	-11.89957*
9	13466.96	8.930877	2.26e-08	-11.93155	-11.83500	-11.89631
10	13474.50	14.93337	2.25e-08	-11.93469	-11.82798	-11.89575
11	13479.78	10.45898*	2.25e-08*	-11.93583*	-11.81896	-11.89318
12	13483.54	7.437849	2.25e-08	-11.93562	-11.80859	-11.88925
IRON ORE						
0	1665.543	NA	7.23e-06	-6.161270	-6.145375	-6.155053
1	3141.403	2935.323	3.10e-08	-11.61260	-11.56492	-11.59396
2	3160.154	37.15431	2.94e-08	-11.66724	-11.58776*	-11.63616*
3	3161.887	3.420963	2.96e-08	-11.65884	-11.54758	-11.61533
4	3167.918	11.86057	2.94e-08	-11.66636	-11.52331	-11.61041
5	3175.898	15.63613	2.90e-08	-11.68111	-11.50626	-11.61273
6	3181.071	10.09593	2.88e-08	-11.68545	-11.47882	-11.60464
7	3189.032	15.47929*	2.84e-08*	-11.70012*	-11.46170	-11.60687
8	3190.209	2.280655	2.87e-08	-11.68966	-11.41945	-11.58399
9	3191.473	2.438683	2.90e-08	-11.67953	-11.37753	-11.56142
10	3194.872	6.533549	2.91e-08	-11.67730	-11.34351	-11.54676
11	3196.052	2.259875	2.94e-08	-11.66686	-11.30128	-11.52388
12	3200.044	7.613410	2.94e-08	-11.66683	-11.26946	-11.51142
LEAD						
0	5949.190	NA	1.71e-05	-5.300526	-5.295431	-5.298666
1	11877.41	11840.60	8.71e-08	-10.58058	-10.56530	-10.57500
2	12007.60	259.7847	7.78e-08	-10.69304	-10.66757*	-10.68375
3	12034.38	53.39290	7.63e-08	-10.71335	-10.67769	-10.70033
4	12049.36	29.84694	7.55e-08	-10.72314	-10.67729	-10.70640*
5	12057.05	15.29765	7.53e-08	-10.72642	-10.67038	-10.70597
6	12063.74	13.31162	7.51e-08*	-10.72882*	-10.66260	-10.70465
7	12064.66	1.826069	7.53e-08	-10.72608	-10.64966	-10.69818
8	12067.37	5.371541	7.54e-08	-10.72492	-10.63832	-10.69331
9	12069.38	3.988130	7.55e-08	-10.72315	-10.62636	-10.68782
10	12074.38	9.913679*	7.54e-08	-10.72405	-10.61706	-10.68499
11	12075.88	2.958854	7.56e-08	-10.72181	-10.60464	-10.67904
12	12077.91	4.027340	7.58e-08	-10.72006	-10.59270	-10.67357
NICKEL						
0	6309.263	NA	2.03e-05	-5.127856	-5.123134	-5.126140
1	13178.06	13720.84	7.66e-08	-10.70899	-10.69483	-10.70385
2	13285.33	214.0901	7.04e-08	-10.79295	-10.76934*	-10.78437
3	13338.62	106.2820	6.77e-08	-10.83302	-10.79997	-10.82101
4	13366.60	55.75040	6.64e-08	-10.85252	-10.81002	-10.83708
5	13379.46	25.62277	6.59e-08	-10.85973	-10.80779	-10.84085
6	13401.22	43.28992	6.49e-08	-10.87417	-10.81278	-10.85186
7	13407.36	12.18830	6.48e-08	-10.87590	-10.80507	-10.85016
8	13417.83	20.80781	6.45e-08	-10.88116	-10.80089	-10.85200*
9	13423.23	10.70792*	6.44e-08*	-10.88230*	-10.79258	-10.84970

10	13426.94	7.369944	6.44e-08	-10.88207	-10.78291	-10.84604
11	13429.59	5.251373	6.45e-08	-10.88097	-10.77237	-10.84151
12	13432.46	5.672868	6.46e-08	-10.88005	-10.76200	-10.83716
SPONGE IRON						
0	846.0997	NA	0.000210	-2.790412	-2.775849	-2.784745
1	3210.980	4706.308	8.58e-08	-10.59498	-10.55129*	-10.57798
2	3218.094	14.11016	8.50e-08	-10.60527	-10.53246	-10.57694
3	3221.165	6.071319	8.52e-08	-10.60220	-10.50026	-10.56253
4	3239.703	36.52299	8.12e-08*	-10.65026*	-10.51919	-10.59926*
5	3242.968	6.412108	8.14e-08	-10.64783	-10.48764	-10.58549
6	3243.808	1.644196	8.23e-08	-10.63738	-10.44807	-10.56371
7	3244.487	1.323420	8.32e-08	-10.62640	-10.40796	-10.54140
8	3250.472	11.63366*	8.26e-08	-10.63296	-10.38540	-10.53663
9	3251.063	1.145655	8.36e-08	-10.62170	-10.34500	-10.51403
10	3253.593	4.882991	8.40e-08	-10.61683	-10.31102	-10.49783
11	3254.648	2.031294	8.48e-08	-10.60710	-10.27216	-10.47676
12	3257.843	6.125750	8.50e-08	-10.60444	-10.24037	-10.46277
STEEL FLAT						
0	1487.293	NA	2.25e-05	-5.026372	-5.011544	-5.020596
1	3930.658	4861.924	5.85e-09	-13.28141	-13.23693*	-13.26408
2	3936.424	11.43432	5.81e-09	-13.28739	-13.21325	-13.25851
3	3944.507	15.97452	5.73e-09	-13.30121	-13.19741	-13.26077
4	3955.945	22.52832*	5.59e-09*	-13.32638*	-13.19292	-13.27439*
5	3958.058	4.147879	5.63e-09	-13.31999	-13.15688	-13.25645
6	3958.321	0.514267	5.70e-09	-13.30735	-13.11458	-13.23226
7	3958.828	0.987394	5.77e-09	-13.29553	-13.07310	-13.20888
8	3960.131	2.531656	5.82e-09	-13.28640	-13.03432	-13.18820
9	3964.089	7.662087	5.82e-09	-13.28626	-13.00452	-13.17651
10	3966.224	4.117875	5.86e-09	-13.27995	-12.96855	-13.15864
11	3968.724	4.805426	5.89e-09	-13.27487	-12.93382	-13.14201
12	3971.885	6.054174	5.90e-09	-13.27203	-12.90132	-13.12762
THERMAL COAL						
0	2430.991	NA	9.70e-06	-5.867127	-5.855729	-5.862756
1	3682.860	2494.668	4.76e-07	-8.881305	-8.847109*	-8.868190
2	3717.243	68.34935	4.43e-07	-8.954692	-8.897699	-8.932834
3	3755.330	75.53031	4.08e-07	-9.037029	-8.957238	-9.006427
4	3778.413	45.66471	3.89e-07	-9.083123	-8.980536	-9.043778
5	3792.526	27.85161*	3.80e-07*	-9.107552*	-8.982167	-9.059463*
6	3795.410	5.676724	3.81e-07	-9.104855	-8.956674	-9.048023
7	3796.536	2.210897	3.84e-07	-9.097913	-8.926934	-9.032337
8	3797.183	1.267862	3.87e-07	-9.089814	-8.896038	-9.015495
9	3798.499	2.571220	3.89e-07	-9.083331	-8.866758	-9.000268
10	3799.512	1.974798	3.92e-07	-9.076116	-8.836746	-8.984310
11	3800.579	2.073999	3.95e-07	-9.069030	-8.806863	-8.968481
12	3803.264	5.207798	3.96e-07	-9.065854	-8.780889	-8.956562
TIN						
0	2941.371	NA	6.81e-05	-3.919162	-3.912078	-3.916523
1	8115.766	10328.09	6.90e-08*	-10.81302*	-10.79177*	-10.80510*
2	8116.201	0.866147	6.94e-08	-10.80827	-10.77285	-10.79507

3	8119.981	7.526028	6.94e-08	-10.80798	-10.75838	-10.78950
4	8120.974	1.973775	6.97e-08	-10.80397	-10.74021	-10.78021
5	8127.547	13.04984	6.94e-08	-10.80740	-10.72947	-10.77837
6	8129.731	4.329869	6.96e-08	-10.80497	-10.71288	-10.77067
7	8133.232	6.931986	6.96e-08	-10.80431	-10.69805	-10.76472
8	8134.212	1.937326	6.99e-08	-10.80028	-10.67985	-10.75542
9	8136.798	5.106740	7.00e-08	-10.79840	-10.66380	-10.74825
10	8138.397	3.153774	7.03e-08	-10.79520	-10.64643	-10.73977
11	8143.908	10.85249*	7.01e-08	-10.79721	-10.63427	-10.73651
12	8147.551	7.164303	7.02e-08	-10.79673	-10.61963	-10.73076
ZINC						
0	6692.986	NA	1.46e-05	-5.457575	-5.452840	-5.455854
1	13652.24	13901.47	5.02e-08	-11.13070	-11.11649	-11.12554
2	13847.63	389.9874	4.30e-08	-11.28681	-11.26314*	-11.27821
3	13908.93	122.2453	4.10e-08	-11.33354	-11.30040	-11.32150
4	13956.77	95.34482	3.96e-08	-11.36931	-11.32670	-11.35382
5	13977.83	41.93173	3.90e-08	-11.38322	-11.33114	-11.36430
6	14001.56	47.19974	3.84e-08	-11.39931	-11.33776	-11.37695*
7	14005.47	7.768569	3.84e-08	-11.39924	-11.32822	-11.37343
8	14008.84	6.705291	3.84e-08	-11.39873	-11.31824	-11.36948
9	14015.07	12.36469	3.84e-08	-11.40055	-11.31059	-11.36786
10	14022.78	15.28196	3.82e-08	-11.40357	-11.30415	-11.36744
11	14030.76	15.79884*	3.81e-08*	-11.40682*	-11.29792	-11.36724
12	14031.58	1.625115	3.82e-08	-11.40422	-11.28586	-11.36121

Notes: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

Annexure- 3 Results of VAR Lag Length Selection for Johensen Cointegration Test to examine the long-run relationship among MCX Commodity Markets and NSE Nifty Market

VAR Lag Order Selection Criteria for MCXAGRI and NSE NIFTY						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-229.32	--	0.0041	0.1935	0.1984	0.1953
1	14574.85	29571.18	1.74e-08	-12.191	-12.177	-12.186
2	14591.61	33.456	1.72e-08	-12.202	-12.178*	-12.193*
3	14592.42	1.6036	1.73e-08	-12.199	-12.165	-12.187
4	14594.19	3.5287	1.73e-08	-12.197	-12.154	-12.181
5	14598.93	9.4353	1.73e-08	-12.198	-12.145	-12.178
6	14607.94	17.928	1.72e-08	-12.202	-12.139	-12.179
7	14612.10	8.2572	1.72e-08	-12.202	-12.130	-12.176
8	14616.90	9.5465	1.72e-08	-12.203	-12.121	-12.173
9	14623.10	12.286*	1.72e-08*	-12.205*	-12.113	-12.171
10	14625.88	5.5124	1.72e-08	-12.204	-12.102	-12.167
11	14628.67	5.5383	1.72e-08	-12.203	-12.091	-12.162
12	14631.10	4.8059	1.72e-08	-12.201	-12.080	-12.157
VAR Lag Order Selection Criteria for MCXCOMDEX and NSE NIFTY						
0	268.44	--	0.0027	-0.2229	-0.2181	-0.2212
1	13649.83	26729.18	3.77e-08	-11.417	-11.402*	-11.412
2	13664.75	29.776	3.74e-08*	-11.426*	-11.402	-11.417*
3	13665.11	0.7103	3.75e-08	-11.423	-11.389	-11.411
4	13667.06	3.8947	3.76e-08	-11.421	-11.378	-11.405
5	13668.93	3.7175	3.76e-08	-11.420	-11.366	-11.400
6	13671.50	5.1143	3.77e-08	-11.418	-11.355	-11.395
7	13676.16	9.2639	3.76e-08	-11.419	-11.346	-11.392
8	13681.05	9.6993	3.76e-08	-11.420	-11.337	-11.390
9	13683.26	4.3982	3.77e-08	-11.418	-11.326	-11.385
10	13685.46	4.3499	3.77e-08	-11.417	-11.315	-11.380
11	13688.68	6.3827	3.78e-08	-11.416	-11.305	-11.376
12	13695.21	12.921*	3.77e-08	-11.418	-11.297	-11.374
VAR Lag Order Selection Criteria for MCXENERGY and NSE NIFTY						
0	-201.3284	--	0.0040	0.1701	0.1749	0.1719
1	11655.88	23684.66	2.00e-07	-9.7487	-9.7343	-9.7435
2	11732.21	152.32	1.88e-07*	-9.8093*	-9.7851*	-9.8005*
3	11736.14	7.8384	1.88e-07	-9.8093	-9.7754	-9.7970
4	11737.56	2.8241	1.89e-07	-9.8071	-9.7636	-9.7913
5	11738.97	2.8087	1.89e-07	-9.8049	-9.7517	-9.7856
6	11740.01	2.0744	1.90e-07	-9.8025	-9.7396	-9.7796
7	11746.13	12.1689*	1.89e-07	-9.8042	-9.7317	-9.7779
8	11750.74	9.1399	1.89e-07	-9.8048	-9.7225	-9.7748
9	11752.18	2.8752	1.90e-07	-9.8026	-9.7107	-9.7692
10	11754.10	3.8064	1.90e-07	-9.8009	-9.6993	-9.7639
11	11756.97	5.6680	1.90e-07	-9.7999	-9.6887	-9.7594
12	11761.03	8.0398	1.90e-07	-9.8000	-9.6791	-9.7560
VAR Lag Order Selection Criteria for MCXMETAL and NSE NIFTY						
0	-13.896	--	0.0034	0.0133	0.0181	0.0150

1	13587.84	27169.32	3.97e-08	-11.365	-11.351	-11.360
2	13610.75	45.732	3.91e-08	-11.381	-11.357*	-11.372*
3	13612.28	3.0404	3.92e-08	-11.379	-11.345	-11.366
4	13615.36	6.1471	3.92e-08	-11.378	-11.335	-11.362
5	13618.67	6.5805	3.92e-08	-11.377	-11.324	-11.358
6	13621.34	5.3136	3.93e-08	-11.376	-11.313	-11.353
7	13624.94	7.1677	3.93e-08	-11.376	-11.303	-11.350
8	13630.01	10.056	3.93e-08	-11.377	-11.295	-11.347
9	13634.92	9.7534	3.92e-08	-11.378	-11.286	-11.344
10	13641.28	12.601	3.91e-08	-11.380	-11.278	-11.343
11	13648.91	15.112*	3.90e-08*	-11.383*	-11.271	-11.342
12	13650.10	2.3550	3.91e-08	-11.380	-11.259	-11.336

Notes: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (ea test at 5% level). FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

Annexure- 4 Results of VAR Lag Length Selection for Johensen Cointegration Test to examine the long-run relationship among MCX Commodity Markets and BSE Sensex Market

VAR Lag Order Selection Criteria for MCXAGRI and BSE SENSEX						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-282.32	--	0.0043	0.2379	0.2427	0.2396
1	14575.90	29679.15	1.74e-08	-12.192	-12.177	-12.187
2	14594.46	37.056	1.72e-08	-12.204	-12.180*	-12.195*
3	14595.79	2.6538	1.72e-08	-12.202	-12.168	-12.190
4	14597.58	3.5673	1.72e-08	-12.200	-12.156	-12.184
5	14602.93	10.639	1.72e-08	-12.201	-12.148	-12.182
6	14612.17	18.384	1.71e-08	-12.206	-12.143	-12.183
7	14615.58	6.7669	1.72e-08	-12.205	-12.132	-12.179
8	14619.08	6.9682	1.72e-08	-12.205	-12.122	-12.175
9	14625.30	12.331*	1.71e-08*	-12.206*	-12.115	-12.173
10	14627.96	5.2686	1.71e-08	-12.205	-12.104	-12.168
11	14630.98	5.9800	1.72e-08	-12.205	-12.093	-12.164
12	14632.69	3.4012	1.72e-08	-12.203	-12.082	-12.159
VAR Lag Order Selection Criteria for MCXCOMDEX and BSE SENSEX						
0	226.69	--	0.0028	-0.1880	-0.1831	-0.1862
1	13648.93	26810.77	3.77e-08	-11.416	-11.402	-11.411
2	13666.06	34.177	3.73e-08*	-11.427*	-11.403*	-11.418*
3	13667.06	2.0128	3.74e-08	-11.425	-11.391	-11.412
4	13669.20	4.2454	3.75e-08	-11.423	-11.380	-11.407
5	13670.93	3.4625	3.76e-08	-11.421	-11.368	-11.402
6	13673.14	4.3830	3.76e-08	-11.420	-11.357	-11.397
7	13677.23	8.1286	3.76e-08	-11.420	-11.347	-11.393
8	13680.62	6.7427	3.76e-08	-11.419	-11.337	-11.389
9	13683.10	4.9229	3.77e-08	-11.418	-11.326	-11.385
10	13685.68	5.1078	3.77e-08	-11.417	-11.315	-11.380
11	13689.77	8.0943	3.77e-08	-11.417	-11.306	-11.376
12	13695.47	11.294*	3.77e-08	-11.418	-11.297	-11.374

VAR Lag Order Selection Criteria for MCXENERGY and BSE SENSEX						
0	-206.18	--	0.0040	0.1742	0.1790	0.1759
1	11656.68	23695.96	2.00e-07	-9.7495	-9.7350	-9.7442
2	11734.37	155.05	1.88e-07	-9.8111	-9.7870*	-9.8023*
3	11738.71	8.6512	1.88e-07*	-9.8114*	-9.7776	-9.7991
4	11740.11	2.7953	1.88e-07	-9.8092	-9.7657	-9.7934
5	11741.26	2.2921	1.89e-07	-9.8069	-9.7537	-9.7875
6	11742.42	2.3065	1.89e-07	-9.8045	-9.7416	-9.7816
7	11747.85	10.789*	1.89e-07	-9.8057	-9.7331	-9.7793
8	11751.14	6.5379	1.89e-07	-9.8051	-9.7229	-9.7752
9	11753.06	3.7997	1.89e-07	-9.8033	-9.7115	-9.7699
10	11755.24	4.3290	1.90e-07	-9.8018	-9.7003	-9.7649
11	11758.61	6.6690	1.90e-07	-9.8013	-9.6901	-9.7608
12	11761.77	6.2616	1.90e-07	-9.8006	-9.6797	-9.7566
VAR Lag Order Selection Criteria for MCXMETAL and BSE SENSEX						
0	-63.630	--	0.0036	0.0549	0.0597	0.0566
1	13584.76	27262.51	3.98e-08	-11.362	-11.348	-11.357
2	13609.17	48.719	3.92e-08	-11.380	-11.355*	-11.371*
3	13611.28	4.2147	3.92e-08	-11.378	-11.344	-11.366
4	13614.11	5.6334	3.93e-08	-11.377	-11.333	-11.361
5	13617.59	6.9347	3.93e-08	-11.377	-11.323	-11.357
6	13619.74	4.2773	3.93e-08	-11.375	-11.312	-11.352
7	13622.75	5.9744	3.94e-08	-11.374	-11.302	-11.348
8	13627.16	8.7530	3.93e-08	-11.375	-11.292	-11.345
9	13632.46	10.526	3.93e-08	-11.376	-11.284	-11.342
10	13639.22	13.408	3.92e-08	-11.378	-11.276	-11.341
11	13647.33	16.058*	3.91e-08*	-11.381*	-11.270	-11.341
12	13647.92	1.1553	3.92e-08	-11.379	-11.258	-11.335

Notes: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion.

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