EFFICIENCY, SEASONALITY AND MACROECONOMIC ISSUES IN INDIAN COMMODITY FUTURES MARKET

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CANDIDATE'SDECLARATION

I hereby certify that the work which is being presented in the dissertation entitled "Efficiency, Seasonality and Macroeconomic Issues in Indian Commodity Futures Market"in fulfillment of the requirements for the award of the degree of Doctor of Philosophy and submitted in the Delhi School of Management, Delhi Technological University (DTU), New Delhi, is bona fide record of my own work carried out under the supervision of Dr. Archana Singh, Assistant Professor, Delhi School of Management, Delhi Technological University (DTU), New Delhi.

The matter presented in this thesis has not been submitted elsewhere in part or fully to any other University or Institute for the award of any degree.

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SUPERVISOR'S CERTIFICATE

This is to certify that the thesis titled "Efficiency, Seasonality and Macroeconomic Issues in Indian Commodity Futures Market", submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy is an original research work carried out by Mr.Narinder Pal Singh, under my supervision. The matter presented in this thesis has not been submitted elsewhere in part or fully toany other University or Institute for the award of any degree, to the best of my knowledge.

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ABSTRACT

Commodity futures markets provide a platform to commodity producers, consumers and traders to hedge their price risk. Price discovery and risk management are two essential roles of the commodity futures market. The commodity futures market has to be efficient to perform these functions. Agro-commodities futures market plays a crucial role in the economic foundations of a country like India that is substantially driven by the agricultural sector performance. At the same time, non-agro-commodity futures markets are imperative to both the policy makers and the other stakeholders in India since they carry a direct implication for the captive consumption and exports. This study analyses the efficiency, seasonality and macroeconomic issues in commodity futures market in India for commodities namely gold, crude oil, copper and chana (chick pea).

The period of this study is 2004-2017. There are 113 commodities traded on commodity exchanges. Owing to time and resource constraints, the scope of this study is limited to four commodities namely gold, crude oil, copper and chana (chick-pea). These commodities (gold, copper, crude oil, and chana or chick pea) belong to precious metals, non-precious metal, energy, and agri-commodities categories respectively. The selected commodities are the top weighted commodities (in Comdex) of their own category collectively accounting for more than 60% weight in Comdex-the commodity index of MCX. As such it may be taken as representative of the commodity market. The data on the select commodities has been collected from Multi Commodity Exchange (MCX), India, National Commodity and Derivatives Exchange (NCDEX) Ltd., India, New York Mercantile Exchange (NYMEX) and Shanghai Futures Exchange (SHFE).

Here, the efficiency of commodity market has been studied by analyzing the price discovery role of futures market. To investigate the efficiency of select futures markets, this study uses Johansen's cointegration and Granger Causality techniques for the two sub-periods, i.e., the pre-crisis period (from 2004 to 14thSeptember 2008) and the post-crisis period (from 15thSeptember 2008 to 2017). Johansen's test results indicate that the spot and futures prices are cointegrated for all the select commodities. In other words, futures and spot prices bear a long-run equilibrium relationship with each other for the select commodities in both the sub-periods. Causality results report that futures marketshave ability to estimate spot prices for gold and copper is higher as compared crude oil and chana, and has improved across the periods. Thus from the results of cointegration and causality, it is concluded that the futures market for all select commodities namely chana, gold, crude oil, and copper are efficient.

Seasonality is an important price determinant amongst factors like government policies like Minimum Support Price (MSP), demand of commodity, the price of substitutes, etc. The seasonality, in turn, may interfere with futures market efficiency. Most of the agri-products traded in the futures market are seasonally grown. For instance, Chana (chickpea) is also a seasonal commodity. During the sowing period, the prices may be trending upwards. But post-harvest, the prices are usually expected to fall. Thus, the seasonality may interfere with futures market efficiency. Therefore, this study also investigates the seasonality effect of chana crop on its futures market efficiency at NCDEX.

To analyze seasonality, a dummy is introduced in the regression model wherein futures price is dependent variable and spot price is the independent variable. The dummy assumes value 1 for the months of the season of the crop (from March to September) and 0 for off-season months (from October to February). To test the linearity of the regression model, Ramsay RESET test has been employed here. The results of the Ramsay RESET test for the given regression model shows that the relationship between natural logarithmic returns on spot price and natural logarithmic returns on futures prices is linear in nature. On introducing dummy variable in the regression model, the results show that there is a significant influence of futures returns on spot prices returns while the impact of seasonality is insignificant. It means the relationship between the chana futures and spot prices is not affected by the seasonality.

Moving to macroeconomic issues related to commodity futures trading, Inflation is a matter of economic concern all over the globe. In 2007, India's parliamentary standing committee on food and public distribution held futures trading responsible for inflation in India. Following the suggestions of the panel and increasing pressure from political circles, the GoI banned futures trading on some essential agro-commodities like wheat, rice and two varieties of lentils while temporarily suspended futures trading in commodities like chana (chick pea), soyoil, rubber, and potato. AbhijitSen committee (2008), the committee by GoI, did not find sufficient evidence of the inflationary effect of futures trading in India. Thus, this study attempts to bridge up the research gap by analyzing the causal relationship between commodity (argi, metals, and energy) futures trading, and commodity specific Wholesale Price Index (WPI) inflation in India.

Toda Yamamoto modified Granger causality technique has been employed on the monthly futures volume and commodity specific WPI data. The results indicate that crude oil futures trading lead to a surge in crude oil prices in the spot market. However, there is no causality from futures trading volume to WPI for chana, gold, and copper. In a nutshell, this study doesn't find any relationship between futures trading and inflation for three out of four select commodities. Thus, this study concludes that commodity futures trading does not lead to higher inflation in India.

Over the last couple of decades, financial integration and volatility of international markets have increased. International linkage of markets proved to be a bane for events like the recent global financial crisis that affected stock and commodity markets almost all over the globe. Thus, the crisis may have affected the spot market volatility of internationally traded commodity crude oil. Moreover, Futures prices play a better role than cash prices, in absorbing and reflecting market information for high trade volume commodities like gold, crude oil, and copper in international markets. Thus, there is a possibility of international associations of gold, crude oil, and copper futures markets of India.

This study employs Johansen's cointegration and Granger causality techniques to analyze the linkage and causality between the select markets. From results, this study concludes that the global financial crisis affected the return on crude oil spot prices but did not affect the volatility of the crude oil spot market. The possible reason for the volatility of crude in 2008 could be financialization of commodity exchanges and excessive speculation in crude oil futures. Without dummy, the results show the presence of ARCH and leverage effects up to three lags. The results also support the existence of volatility clustering.

Thus, from the results of linkage analysis of Indian commodity futures market with international markets this study concludes that futures markets of copper and crude oil are not efficient as their market at MCX and their respective foreign futures market are cointegrated. However, the gold futures market at MCX and NYMEX are not cointegrated and hence efficient. However, the gold futures market at NYMEX leads MCX market.

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ABBREVIATIONS USED

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroskedasticity
ARMA	Autoregressive–Moving-Average
BEKK	Baba, Engle, Kraft and Kroner
BSE	Bombay Stock Exchange
CBOT	Chicago Board of Trade
CME	Chicago Mercantile Exchange
CPI	Consumer Price Index
CTT	Commodities Transaction Tax
DCE	Dalian Commodity Exchange
DF	Dickey-Fuller
EGARCH	Exponential Generalized Autoregressive Conditional Heteroskedasticity
EMH	Efficient-Market Hypothesis
EViews	Econometric Views
EU	European Union
FIGARCH	Fractionally Integrated GARCH
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GoI	Government of India
GQARCH-M-ECM	Quadratic GARCH in Mean Error Correction Models
HANG	Hong Kong stock market
IIM	Indian Institute of Management
IIP	Index of Industrial Production
IPE	International Petroleum Exchange
KCE	Kanmon Commodity Exchange
LM	Lagrange Multiplier
LME	London Metal Exchange
MCX	Multi-commodity Exchange
MENA	Middle East and North African
MGARCH	Multivariate GARCH

MIFE	Manila International Futures Exchange
MS	Micro Soft
MSP	Minimum Support Price
NBOT	National Board of Trade
NBSK	Northern Bleached Softwood Kraft
NCDEX	National Commodity & Derivative Exchange Ltd.
NMCE	National Multi Commodity Exchange of India Limited
NYMEX	New York Mercantile Exchange
OTC	Over the Counter
OSB	Oriented Strand Board
PP	Phillips Perron
p-value	Probability Value
R^2	Coefficient of Determination
SAARC	South Asian Association for Regional Cooperation
SBIC	Schwarz Bayesian Information Criterion
SEBI	Securities and Exchange Board of India
SHFE	Shanghai Futures Exchange
SUR	Seemingly Unrelated Regression
TY	Toda Yamamoto
TGE	Tokyo Grain Exchange
TOCOM	Tokyo Commodity Exchange
UK	United Kingdom
USA	United States of America
USD	US Dollars
VAR	Vector Auto Regression
VEC	Vector Error Correction
VECM	Vector Error Correction Mechanism
WCE	Winnipeg Commodities Exchange
WPI	Wholesale Price Index
WTI	West Texas Intermediate
ZCE	Zhengzhou Commodity Exchange

CHAPTER 1

INTRODUCTION

Commodities can be called as the fifth element of life on this planet; earth (soil), air, water and fire being the first four elements. There arises demand for these commodities due to different purposes they are used for depending on their type i.e. agricultural or non-agricultural (metals, energy etc.). The demand and supply forces results in a price under the market equilibrium condition. The markets where these commodities are traded are broadly of two types, spot and futures market. On time axis, the former which deals with buying and selling of commodities today lies at zero (t = 0) and the latter which deals with exchange of commodities on a future date for a price fixed today (futures price) lies at time 't' (t being the time to maturity).

The price at which a commodity is traded in spot market is called spot price. In futures market, futures contracts are traded at futures price. A futures contract provides the contract buyer (or seller) a right and obligation to buy (or sell) the underlying (commodity) on a future date at a price fixed today. The futures price is mutually agreed by both the parties of futures contract. In commodity futures market, the underlying asset is a commodity. In India, commodity futures are available on four different categories of commodities viz. i) agricultural commodities like chana, wheat, barley, castor seeds, coriander, guar gum, soy bean etc., ii) Precious metals like gold and silver iii) Base (non-precious) metals like copper, zinc, aluminium etc. and iv) Energy like crude oil and natural gas.

1.1. Efficiency

Commodity futures markets provide a platform to commodity producers, consumers and traders to hedge their price risk. Price discovery and risk management are two essential roles of the commodity futures market. The basic requirement of commodity futures markets to perform these functions is market efficiency (Newbold et al. 1999). An efficient market is the one which fully reflects the available information (Fama, 1969). According to Expectation Hypothesis, a futures market is defined as efficient if the current futures price (t=0) of a futures contract of maturity t provides an unbiased forecast of the futures spot price at time t. In other words, in an efficient futures market, current futures price encompasses the past information and thus the lagged values of futures price do not affect future spot price (McKenzie and Holt, 2002). Thus, an efficient futures market ensures that no arbitrage profit can be made by trading between spot and futures markets using publically available information (Malkiel, 1992 and Wang and Ke, 2005). The convenience and low cost of the transaction in futures markets aid in rapid price adjustments that quickly eliminate the chances of making arbitrage profit. Chapter 4 deals with commodity futures market efficiency in more details.

1.2. Seasonality in Commodities

Most of agri-products traded in futures market are seasonally grown. The seasonality pattern of crop depicts the season of its sowing, growing and harvesting. During this period, the prices of agri-product may be rising subject to the demand and supply forces. But post-harvest, the prices are usually expected to fall. For instance, Chana (chickpea) is also a seasonal commodity. It is a rabi crop and grown in winters in the month of September/October to November in India. It is usually harvested during February to April. Thus, agricultural commodities may possess seasonality effect. Seasonality is "the systematic, although not necessarily regular, intra-year movement caused by changes of the weather, the calendar and timing of decisions, directly or indirectly through the production and consumption decisions made by the agents of the economy" (Hylleberg, 1992). Commodity futures have characteristic seasonal effect unlike financial futures (Newbold et al., 1999). The seasonality in turn may interfere with futures market efficiency.

Indian government exercises Minimum Support Price (MSP) policy for more than 20 crops every year. MSP is the minimum price farmers can fetch by selling their produce. In other words, it is the price at which GoI will procure farmers produce. This is to encourage production, support and protect farmers' interest in choosing a crop of his choice as per the market demand conditions. However, this is the government's practice to regulate the market and confine free price movement. This, in turn, obstructs price discovery mechanism in those commodities. Moreover, the farmer is a price taker and not the price giver under this policy. There comes a tool of price risk management and price discovery, called futures contract. A producer (farmer), consumer or trader may trade in the futures market to cover his price risk and discover the future spot price. But, this is only possible if the futures market is efficient.

Thus, seasonality is an important price determinant amongst factors like MSP, the demand for the commodity, the price of substitutes, etc. The seasonality, in turn, may interfere with futures market efficiency. However, there is a dearth of research on the effect of seasonality on futures market efficiency. Moreover, there is no study on futures market efficiency and seasonality relationship in India. Chapter 4 deals with commodity futures market efficiency in more details.

1.3.Macroeconomic Issue- Inflation

The commodity futures markets provide a platform for its participants like hedgers, speculators, and arbitrageurs to trade in commodities. Hedgers trade in the futures market to cover the risk linked to their spot market position. The speculators and arbitrageurs maintain liquidity in the market and drive the markets to attain efficiency. But, futures markets have been condemned for pushing up prices of commodities resulting in inflation. In early 2007, India's parliamentary standing committee on food and public distribution held futures trading responsible for inflation in India. Following the suggestions of the panel and increasing pressure from political circles, the Government of India banned futures trading on some essential agro-commodities like wheat, rice and two varieties of lentils. However, futures trading in commodities like chana (chick pea), soyoil, rubber, and potato were temporarily suspended.

An expert committee led by Prof. Abhijit Sen was constituted to analyse the connection between futures trading and agricultural commodities inflation in India. The committee did not find sufficient evidence of inflationary impact of futures trading in India. Too short period of commodity futures trading was reported as the main hurdle to differentiate the effect of futures trading and cyclical adjustment (Sen, 2008). Thus, there is a scope to study the inflationary impact of futures trading for a longer period of more than ten years post introduction of agricultural futures.

The need to analyse the inflationary effect of futures trading further gets support from continued rising prices even after 2008 and the opinions of bad effects of speculation. The rising food product prices with an average inflation rate of 12.46% during March 2008 and November 2011, maximum WPI inflation of 9.6% (2010-11) and maximum CPI of 13% (2009-2010) were recorded. Though speculators bring liquidity and price stability in the market, there is a strong popular belief that they are responsible for an increase in prices (Bose, 2007). The belief about the negative impact of speculation stems from the argument that huge positions in futures contracts (open interest) result in an increase in futures prices which in turn affects spot prices. Also, there is a strong belief that speculators manipulate prices by exercising malpractices like hoarding that further pushes up the prices. This calls for a serious examination of the nexus between futures trading and inflation. Chapter 5 deals with commodity futures market efficiency in more details.

1.4. International Linkage and Global Financial Crisis

Volatility is a matter of concern for all the countries and especially for an emerging market like India. Over the last couple of decades, financial integration and volatility of international markets have increased. Changing technology, high pace information transmission, relatively free flow of capital across the world markets, and globalization of the world economy have made over the globe financial markets highly integrated. This linkage often leads to return and volatility spillover and a lead-lag relationship among different markets (Mensi et al., 2013). The stock market international linkage has been a topic of interest of many researchers over decades all over the globe. A huge literature is available on stock market integration. Comparatively, research on the commodity futures market's international integration started late.

In the recent past, commodity markets have registered a fast escalation in liquidity. Market integration has made the effects of high swings in commodities like gold and crude oil wide spread across the globe. For instance, in the year 2016 crude oil prices slipped below $35 per barrel due to high tension between Iran & Saudi Arabia, dipping economic growth of China and due to Brexit announcement. Thus, fluctuations in commodity prices, unless managed, have the potential to disturb the smooth functioning of the nation's economy (Kumar, 2014). To manage such fluctuations, commodity futures markets are used. Futures prices play a better role than cash prices, in absorbing and reflecting market information for high trade volume commodities like crude oil in international markets (Yang et al. 2001). Thus it becomes critical to analyze the international linkages of domestic futures markets with its world counterparts.

International linkage of markets proved to be a bane for events like the recent GFC that impacted stock and commodity markets almost all over the globe. It dried up liquidity and increased volatility in markets (Sharma and Misra, 2011). The equity markets were severely hit. Thus, most of the literature is found to be focused on the influence of the recent GFC on the stock market. However, the commodity market has not got due weightage as far as the effect of GFC of 2008 is concerned. Chapter 7 deals with commodity futures market efficiency in more details.

1.5. Indian Commodity Futures Market

Commodity derivatives trading is not new in India. However, the concept of organized futures trading was introduced in 1875 (Sahadevan, 2002). Though it fuelled setting up of commodity exchanges in different parts of the country, the Indian commodity derivatives (futures and options) market experienced many bans and prohibitions on some specific commodities. After liberalization, on the recommendations of Kabra committee (1993) futures trading was allowed in all recommended commodities.

Online trading in commodity futures started with the incorporation of three national electronic commodity exchanges in 2002. These exchanges are National Multi Commodity Exchange of India Limited (NMCE) - the first to start online trading in India, National Commodity & Derivative Exchange Ltd. (NCDEX) - the leading agro-commodity exchange, and Multi-commodity Exchange (MCX) - the leading metals and bullions exchange. Since the beginning of their operations in 2003, the Indian commodity futures market has experienced remarkable growth in trade volume as well as a number of commodities traded and commodity exchanges. There are 22 Commodity Exchanges (6 National and 16 Regional Exchanges) in India where more than 110 commodities are traded. Recently, three more electronic commodity exchanges have joined the fleet of national commodity exchanges. All the commodity exchanges were being regulated by Forward Market Commission alone before its merger with SEBI on 28th September 2015. Now SEBI is the regulator of the commodity derivative market.

1.6. Scope of the Study

This study examines efficiency, seasonality, the inflationary impact of commodity futures trading, the influence of the recent GFC on the spot volatility market, and international associations of Indian commodity futures markets. There are 113 commodities traded on commodity exchanges. Owing to time and resource constraints, the scope of this study is limited to four commodities namely gold, crude oil, copper and chana (chick-pea). These commodities account for more than 60% weight in Comdex-the commodity index of MCX. As such it may be taken as representative of the commodity market.

Accordingly, the commodity futures market efficiency has been studied in respect of each of the selected commodities, i.e., chana, copper, gold and crude oil. There are several macroeconomic variables namely exchange rate, inflation rate, gross domestic product (GDP) and interest rate which can affect commodity prices (Frankel, 2006; Akram, 2008; Fabozzi et al., 2008, Bhardwaj and Dunsby, 2012). On the other hand, commodity trading can also affect some of these macroeconomic variables. It can be discerned from the literature that inflation is the only macroeconomic variable which can be affected by commodity futures trading. In India, there have been allegations on commodity futures trading of inflationary impact in 2007. Even the GoI banned futures trading on some essential agro-commodities like wheat, rice and two varieties of lentils and temporarily suspended futures trading in commodities like chana (chick pea), soyoil, rubber, and potato. However, the Abhijit Sen committee failed to find sufficient evidence of inflationary impact of agricultural futures trading on prices of agri-commodities. Thus, this study analyses the effect of commodity futures market trading on inflation.

The impact of seasonality has been studied for agri-commodity chana. This is because chana is a seasonal commodity which is grown in winters in September/October to November and harvested from February to April in India. During this period, the prices of chana may be rising subject to the demand and supply forces. But post-harvest, the prices are usually expected to fall. This study also analyses the effect of the GFC 2018 on the spot market volatility of crude oil - internationally traded commodity. Crude oil is one of the major source of energy globally. India's energy requirement is also largely met through crude oil. Further, crude oil price rise unless managed may lead to inflation. At last, this study analyses international linkages of gold, crude oil and copper futures market in India with their world counterparts.

1.7. Objectives of the Study

The concept of organized commodity futures market is relatively new to India. Agro-commodities futures market contributes substantially in the economic foundations of a country like India that is substantially driven by the agricultural sector performance. At the same time, non-agri-commodity futures markets are important to its various stakeholders in India since they carry a direct implication for the captive consumption and exports. In the light of the previous researches and issues stated in the previous section, this study achieves the research objectives that inter-alia include the following: -

a) To examine the efficiency of commodity futures market for gold, crude oil and copper traded on MCX and chana (chick-pea) traded on NCDEX in India.
b) To investigate the effects of seasonality in testing efficiency for Chana (chickpea) traded at NCDEX.
c) To examine the inflationary impact of commodity futures market trading volume.
d) To analyse the impact of the recent global financial crisis on the volatility in crude oil spot market in India.
e) To examine the co-integration effects and its consequential impact on efficiency in selected non-agro commodities (gold, crude oil and copper).
f) To suggest possible policy measures and solutions for improving the operations of commodity futures market in India.

1.8. Research Methodology

The objectives of this study warrant the use of quantitative and causal research methodology employing secondary data. According to Kothari (2004), "quantitative research is based on the measurement of quantity or amount". In other words, it is limited to what can be measured or quantified (Winter, 2000). According to Ghauri and Gronhaug (1995), "the causal research is used when the problems are under structured."

Table 1.1: Commodity Market and Period of Sample Data

Comm-odity	Type of Commo-dity	Market		Period		Number of observations
		Spot Market	Futures Market	From	To	
Chana	Agro	Delhi	NCDEX	21st May 2004	20th July 2016	3423
Gold	Precious Metal	Ahmedabad	MCX	6th June 2005	31th March 2017	3,325
Crude Oil	Energy	Mumbai	MCX	16th May 2005	31th March 2017	3,444
Copper	Non – Precious Metal	Mumbai	MCX	1st July 2005	31th March 2017	3,363

The period of this study begins from the year of commencement of futures trading in the select commodities on MCX / NCDEX, India (see Table 1.1). Chana futures trading began on

NCDEX in 2004, while gold, crude oil and copper futures trading started in 2005 on MCX. Accordingly, data were collected from the date the spot prices became available on these exchanges until 2017. The present study spans over 2004 to 2017. However, in case of chana the data was not available beyond July 2016 because of ban on its trading in futures market. The selected commodities are the top weighted commodities (in Comdex) of their own category collectively accounting for more than 60% weight in Comdex-the commodity index of MCX. Table 1.1 shows the details on data period, number of observations, and commodity market.

Before analyzing the variables for a particular research objective, the preliminary analysis has been conducted. In this study, the preliminary analysis includes summary statistics and testing for outliers and testing the unit root properties.

For analyzing efficiency and seasonality, spot and futures daily prices have been obtained from MCX (for gold, crude oil, and copper) and NCDEX (for chana). This study analyses the efficiency of commodity futures markets through price discovery mechanism. For efficiency analysis, cointegration and causality analysis has been done for the two sub-periods, i.e., the pre-crisis period (2004 to 14^{th} Sept., 2008) and the post-crisis period (15^{th} Sept 2008 to 2017). This study uses Johansen's cointegration and Granger causality techniques to test cointegration and causality between the futures and spot prices, respectively. For seasonality analysis, first Ramsay's RESET test is employed to formally test whether a linear form of regression model fits the data and then run regression model with the dummy is used under the null hypothesis of no effect of seasonality on the spot price.

To analyse the inflationary effect of commodity futures market trading, the monthly data on select commodity WPI inflation is obtained from the Office of the Economic Advisor, GoI. This study uses Toda Yamamoto modified Granger causality test to investigate the inflationary impact of commodity trading in India for the select commodities and sample period of the study. To examine the effect of the recent GFC on the volatility in crude oil spot market in India, data collected from MCX has been analyzed using Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH). EGARCH model has been employed for the spot market log return with and without dummy. The dummy takes a value of zero for pre-crisis period i.e. (May 16, 2005 to September 14, 2008) and one for post-crisis period (September 15, 2008 to 31 March, 2017).

To analyse the cointegration effects with international commodity markets for gold , crude oil and copper, the required data on gold futures (NYMEX-Comex) and copper futures (SHFE, Shanghai) has been collected from Bloomberg database while Light & Sweet crude oil futures (NYMEX) data has been collected from Energy Information Administration, USA. Johansen's cointegration and VEC/VAR Granger causality have been used to analyze international linkage and causality relationship respectively, between Indian commodity futures market and its world counterparts over the recent eight years in the post-crisis periods, i.e., April 2009 to March 2017.

This study makes use of MS Excel (for descriptive statistics, and graphical analysis) and Eviews 8.0 (for econometric modeling and analysis) to process and analyze data.

1.9. Chapter Scheme

The following is the outline of the chapter scheme that has been followed in the study.

Chapter 1 Introduction

In this chapter, the various concepts like market efficiency, seasonality, inflation, and futures trading, international linkage, and global financial crisis have been introduced. It also gives an overview of Indian commodity futures markets. Further, it contains scope, research objectives, research methodology and chapter scheme of this study.

Chapter 2 Literature Review

This chapter gives the extensive review of literature relating to all the objectives of this study and research gap identified from the literature.

Chapter 3 Research Methodology

It deals with research methodology of this study on efficiency, seasonality, inflationary impact, global financial crisis and international linkage of the Indian commodity futures markets. It also includes details on the sources of data and period of data.

Chapter 4 Efficiency and Seasonality Analysis

In this chapter, analysis of the efficiency of gold, crude oil, chana and copper futures markets has been provided for the select period of study. This chapter also examines the effect of the seasonality of argi-commodity chana (chickpea) on its futures market efficiency.

Chapter 5 Commodity Futures & Inflation Impact Analysis

This chapter provides detailed investigation on the effect of gold, crude oil, chana and copper futures trading on commodity specific WPI Inflation in India.

Chapter 6 International Linkage and Volatility Analysis

It analyses international linkage of the crude oil futures market in India and USA. It also studies the influence of the GFC on the volatility of the crude oil spot market.

Chapter 7 Conclusions and Recommendations

In this chapter, the conclusion from important findings, and limitations of the study has been provided. This chapter further explains research implications for the purpose of evolving an appropriate official policy towards organization and regulation of commodity futures market. The recommendations for the government and regulatory bodies are also highlighted in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many studies that investigate futures markets and related aspects in developed as well as emerging markets. This chapter reviews the literature on empirical studies on the efficiency, seasonality and macroeconomic issues in the commodity futures market in India. Accordingly, the literature has been divided into different sections. The first section includes the literature on efficiency of commodity derivatives markets, the second section emphasizes on the literature on studies on inflation and commodity futures trading, third section deals with studies on seasonality effect on commodity futures, fourth section focuses on international linkage of Indian commodity futures market and finally the fifth section presents available literature on the impact of recent GFC on commodity market volatility.

2.2 Literature Review on Efficiency

Futures market efficiency is the most important aspect of commodity market in both developed as well as emerging markets. Some of the important researches relating to efficiency and seasonality have been summarized below.

Just and Rausser (1981) study the forecasting power of futures price vis-a-vis econometric models for the select sample of 8 commodities. They report that futures market gave better forecasts for soybean meal and oil, while some econometric forecasts were better for live cattle and hogs. The results are mixed for the rest of the sample commodities. Goss (1981) found that the futures market of copper, zinc, tin, and lead are efficient. However on the contrary, in his later study, Goss (1985) he finds lead and tin futures market to be inefficient.

Bigman, Goldfarb, and Schechtman (1983) analyze wheat, corn and soybean futures markets efficiency from 1975 to 1980 using OLS regression. They report that these markets are efficient for contracts up to six-week expiration but inefficient for longer expiry. It is also found that for longer expiry contracts futures prices are affected by the then prevailing spot prices. Fama and French (1987) report that futures prices of ten out of twenty-one commodities exhibit spot price forecast power.

Oellermann, Brorsen, and Farris (1989) examine causality between cash and futures market prices for feeder and live cattle. The results report that the futures price Granger causes cash price for feeder cattle and futures market plays price discovery function for live cattle. Allen and Som (1987) examine London Rubber Market for weak form efficiency. They analyze daily cash price (from 1975 to 1983) and futures prices changes (form 1980 to 1983) using different tests. The results show that the market is weak form efficient.

Naik and Leuthold (1988) investigate cash (Omaha Market) and futures markets (CME) of cattle and hog for the period from 1966 to 1986. Their study is focused on testing the presence of components like basis risk, i.e., the difference of futures price and cash price. They suggest that a speculative component and maturity basis risk is present in both commodities (non-storable) and vary from contract to contract. The results also show the presence of seasonality in coefficients of correlation in the case of hog only.

Schroeder & Goodwin (1991) explore cash and futures live hogs markets. They study cointegration and price discovery between daily Omaha market cash prices of slaughter hog and Chicago Mercantile Exchange futures prices of a live hog for the period of 1975 to 1989. The results show that the two price series are not cointegrated, but there is information transmission from futures to cash market and occasional feedback flow from cash to futures.

Yohannes (1992) analyses the coffee futures market efficiency and causality association between futures and spot prices over a different length of periods. He concludes that price discovery takes place in coffee futures in long-run. In short-run, futures prices Granger cause spot prices.

Tomek (1996) reports that "a futures price can be an unbiased forecast of the maturity month price, but has a large variance of forecast error." He suggests that some quantitative models could be built that do better forecast than futures price and result in lower forecast error variance. Mananyi and Struthers (1997) investigate London cocoa beans market the London Futures and Options Exchange for market efficiency using cointegration approach and found evidence of inefficient market. According to them, supply shocks may be hindering futures price to converge to spot price and thus creating scope for arbitrage opportunities.
Sahadevan (2002) examines the efficiency of agricultural commodities futures market at seven exchanges in India. He finds that futures markets of these commodities are inefficient. Further, for six commodities traded in twelve markets, he reports that there is no integration between futures and cash market prices. Also, there is no effect of cash prices volatility on futures market conditions. He identifies some significant hurdles in the growth of the futures

market at these exchanges. These barriers are thin markets, irregular trading activities and state interference in these exchanges.

Singh (2002) in his doctoral thesis suggests that out of the sample commodities, castor seed (Ahmedabad and Mumbai) and pepper futures markets are efficient and unbiased while gur (Hapur & Muzaffarnagar) and turmeric markets are inefficient and biased. He and Holt (2004) examine lumber, OSB and NBSK weekly spot and futures prices to test market efficiency. They conclude that the two series are neither cointegrated nor unbiased, i.e., markets are inefficient.

Mckenzie and Holt (2002) analyse the agro-commodity futures market at CBOT and CME for efficiency and unbiasedness for the period 1959-2000. Using Johansen's cointegration methodology, they suggest that markets for select commodities are efficient and unbiased long run. Using QGARCH-M-ECM, they, however, find that corn and cattle futures markets to be inefficient and biased in short-run.

Armstrong et al. (2003) report that the sugar futures market effectively performs price risk management function in the Dominican Republic. Wang and Ke (2005) report that the futures market of soybean is weakly efficient while that of wheat is inefficient due to over-speculation and government intervention.

Xin, Chen, and Firth (2006) examine Chinese copper and aluminum futures market for efficiency. The results show that these markets are efficient during 1999–2004. Lokare (2007) reports that spot and future prices are cointegrated for wheat, pepper, sugar (S), mustard, cotton, rubber, gur, sesame oil, sesame seed, copper, tin, lead, zinc, aluminium, gold, silver, Brent crude oil, and furnace oil markets in India. Singh (2007) explored arbitrage opportunities across MCX, NCDEX and NBOT exchanges and found evidence of cointegration between the soya oil futures prices on these exchanges. He also examines the hedging efficiency of three domestic and one international exchange CBOT. The results suggested that CBOT has relatively high hedging efficiency than these three exchanges.

Switzer and Fan (2009) examine the effect of the introduction of screen-based trading on information efficiency of futures markets at Montreal Exchange, Canada for the sample period 1999 to 2006. Their results indicate that futures contracts suffer from a small positive pricing error. They further report a decrease in this mispricing and conditional volatility of mispricing after the commencement of screen-based trading. From results, they infer that screen trading has led to a decrease in the effects of dividend yield and time-to-maturity biases.

Sahoo and Kumar (2009) investigate futures market efficiency and the association between price rise and commodity futures trading for a sample of five commodities for a period of May 1, 2006, to April 30, 2008. Using the Granger causality test, they conclude that futures trading has no influence on rise in spot prices of commodities. However, the futures price is found to Granger cause spot price for all the select commodities and futures markets are efficient.

Ghosh (2010b) analyses the wheat futures market price discovery function. The sample period of his study is from May 21, 2009, to March 4, 2010. Using Granger causality test, VAR and seemingly unrelated regression (SUR), he infers that there is no information flow between the futures and spot market of wheat. The study reports that wheat futures market is inefficient and does not perform price discovery function.

Kaur and Rao (2010) examine the efficiency of agri-commodities futures markets. The results of autocorrelation show that the futures markets of pepper, guar seed and chana are efficient. However, run test results report the efficiency of the select agri-commodities futures market.

Pavabutr and Chaihetphon (2010) study standard and mini gold contracts for a period 2003-2007 at MCX. They report that the standard gold futures market performs price discovery function and mini gold contracts aid up to 30% in the price discovery process at MCX, India. They explain that this significant role of mini contracts is probably due to more frequent trade leading to efficient information flow in the market.

Narayan et al. (2010) investigate the association between gold and crude oil spot and futures markets (with different maturities). They conclude that gold and crude oil markets are jointly inefficient as one market can predict the other for the sample period 1963–2008 for the US. Also, they report the use of the gold market as a hedging tool against inflation as the main reason behind the linkage between the two commodities.

Ali and Gupta (2011) in their study on agro-commodities report efficiency for all select commodities futures markets except for that of rice and wheat. They also reported that for 6 out of 12 select commodities (Sugar, Castor Seed, Wheat, Soybean, Guar Seed and Chickpea), futures prices granger cause spot prices and for other 3 (Cashew, Rice and Red

Lentil) spot prices granger cause futures price. However, the relationship is bi-directional for the rest of the select commodities.

Sehgal et al. (2012) study agri-commodities futures market for 2003-2011. They find that markets were efficient for 9 out 10 select agri-commodities with bi-directional causality between spot and futures markets. Yaganti & Kamaiah (2012) examine the hedging effectiveness of spicy and base metals futures contracts with varying maturity from 1 to 3 months. They conclude that a) only 40% of contracts are suitable for hedging b) far month and nearby month contract have the same hedging performance in case of spices, c) for base metals, there is minute difference in hedging performance across different maturity contracts d) hedging is more effective in case far and nearby month contracts.

Soni and Singla (2012) investigate and conclude that Guar gum futures market is inefficient. The possible reason for market inefficiency is attributed to over-speculation/market manipulation. In a study on agro-commodities futures and farmers, Murthy and Reddy (2012) find that in the case of chilli and turmeric, futures prices influence spot prices. They report that "the majority of the farmers are not aware of the commodity futures trading and hence do not participate in futures trading." Similar results on efficiency are found by Gupta and Ravi (2013) in a study on agro-commodity futures market at three leading national commodity exchanges in India.

Arora and Kumar (2013) investigate the price discovery in copper and aluminium metals futures markets at MCX for six years. They use Johansen's cointegration and VECM model. They report that both the market are efficient and perform price discovery function. Peri et al. (2013) analyse linkage between spot and futures markets of corn and soybean using cointegration approach. They used Kejriwal and Perron (2010) procedure for testing multiple structural breaks and Toda Yamamoto modified Granger causality. They conclude that the futures market performs price discovery function while the fundamentals play an important role during a recent global increase in food prices.

Mahalik et al. (2014) report that agri, metals and aggregate commodity index futures markets effectively carry out price discovery function in their spot markets. However, the metal index futures market does not possess long-run equilibrium with its spot market. They further conclude that in energy and aggregate index (Comdex) there is volatility spillover from futures to spot market while it is just opposite in case of agri-index.

Kakati (2014) in her study on 20 commodities (15 agro and five non-agro commodities) from 2003 to 2010 employs a signaling model and Granger causality test. She reports that for 16 out of 20 sample commodities, futures and spot prices converge at maturity. Further, she states that price discovery takes place in the futures market in the case of 7 commodities and spot market in case of 2 out of 15. However, for the remaining six agricultural commodities, five commodities don't show any association between spot and futures markets while mustard seed shows bidirectional information flow. Granger causality results indicate that only six agro-commodities futures markets perform price discovery role.

Broll et al. (2015) study future hedging by a competitive firm under different situations relating to the expectation dependence of futures or spot prices on basis risk. They show that the firm's optimal futures position depends on the nature and sign of expectation dependence. An under or over-hedge is optimal if there are either ‘spot or futures prices' or only futures price is negatively or positively expectation dependent on the basis risk respectively.

Malhotra and Sharma (2016) examine gaur seed futures market at NCDEX for efficiency and volatility spillover for a sample period 2004 to 2011. Using Johansen’s cointegration technique, they find cointegration between the spot and futures guar market. They find that the slow error correction takes place in both the markets, the speed of adjustment being higher in the futures market. Further, Granger causality results indicate that futures prices Granger cause spot prices. GARCH model results report two-way volatility spillover between the two markets. They infer that the guar seed futures market performs price discovery function while spot market causes increased volatility in the futures market.

Arora and Sandhar (2017) investigate hedging efficiency of crude oil futures traded at MCX, India. They collect monthly futures prices from MCX and spot prices from energy information administration of USA for 10 years sample period (2005 to 2014). Their results of Ederington’s hedging efficiency measure, hedge ratio, and regression analysis indicate that the crude oil futures market at MCX efficiently performs hedging function.

2.3 Literature Review on Seasonality

French (1986) in his study on spot price forecast reported that "Futures prices cannot provide reliably better forecasts unless the variance of the expected spot price changes is large relative to the variance of the actual spot price changes. This relative variance is related to many factors, including the importance of seasonals in production and the cost of storage.

Seasonals in demand and supply may generate reliable forecast power in futures prices." His findings are found to be consistent with that of Fama and French (1985).

Newbold et al. (1999) analyze the influence of seasonality on the efficiency of selected commodities using quasi-ECM augmented with seasonality dummy term. They find evidence of seasonality in case of the selected commodities like soybeans, live cattle, live hogs, and heating oil, and hence inefficiency (expect soybean). Sorenson (2002) develops a model to estimate seasonality. He reports backwardation in the long run and contango in short run contracts. He finds evidence of backwardation in case soybeans and wheat and mixed results in case of corn.

Todorova (2004) compares Schwartz-Smith two factor model forecasting ability with that of parametric and non-parametric seasonality models for crude oil and natural gas. He reports the presence of seasonality in natural gas pricing. He also finds that volatility functions model outperforms others in terms of predicting ability. Nath and Lingareddy (2008) investigate the effect of the commencement of future trading on spot markets of urad, wheat, and chana. They suggest that futures trading has resulted in a price hike in case of urad only and increase in volatility in all the three commodities. They also report no effect of futures trading on seasonal fluctuations of the selected commodities.

A study conducted by Mirantes, Población and Serna (2012) finds evidence that convenience yield gives a better commodity price seasonality estimate as compared to futures price for the sample commodities heating oil, WTI crude oil, Henry Hub natural gas and RBOB gasoline at NYMEX. The reason they attribute for this is that futures prices are governed by a number of factors like weather conditions, political factors, etc. in addition to demand and supply. They also report stochastic seasonality with one year period in the select commodities.
Back, Prokopczuk and Rudolf (2013) study American options and futures contract markets of heating oil and soybean. They conclude that seasonality in volatility plays an imperative role in commodity options pricing.

Bhattacharya et al. (2016) compare the direct and indirect method of seasonal adjustment of time series of exports, the Consumer Price Index (CPI), the Index of Industrial Production (IIP), and the Wholesale Price Index (WPI). They find that black box seasonal adjustment using eviews works good but cautious seasonality analysis works better in improving variance of series. They further report that for IIP series direct method removes noise better than the indirect method of adjustment.

2.4 Literature Review on Inflation

Dasgupta (2004) examines the relationship among commodity futures trading, spot price stabilization, production, and inventory decisions. His results indicate that futures trading has a stabilizing effect on commodity spot price where the future market is assumed to monopolistic competition market. He reports "there is a co-movement among futures price, production decision and the inventory decision." His results further indicate that under monopolistic competition condition, both the spot and futures markets achieve stable equilibrium and unnecessary hoarding tends to increase carrying cost and reduce futures price elasticity of inventory.

Yang et al. (2005) in their study on select commodities futures markets use Granger causality and variance decompositions techniques. They divide the whole period (January 1, 1992, to December 31, 2001) into two periods (1992-1995 and 1997-2001). They conclude that unexpected rise in futures trading volume granger cause cash price volatility for all but hogs and soybeans, and confirmed the destabilizing effect of futures trading on US commodity markets. However, the conflicting results were reported by Ranjan (2005) for soya oil market in India. He found the stabilizing impact of futures trading of soya oil on seasonal price volatility and daily price fluctuations.

Sahi and Raizada (2006) analyse futures market efficiency using Johansen's cointegration tests and inflationary impact using OLS multiple regression model for three-month wheat futures. They report that “wheat futures market is not even weakly efficient in the short term (one week, two and one months before maturity) and in fact, spot price leads futures price determination”. They conclude that wheat futures market has a poor price discovery process, and effects inflation as growth in futures volume in trade is an important determinant of inflation.

Gorton and Rouwenhorst (2006) report that commodity futures returns show a negative correlation with the returns on stocks as well as bonds, and positive correlation with inflation being higher for a longer horizon. They also compare the risk and return of commodity futures with other Asset classes like stocks and bonds. They report that risk premium on commodity futures is the same as equity but exceeds bonds.

Karande (2007) in her doctoral thesis reports that castor seeds futures trading at Ahmedabad and Mumbai does not have a destabilizing effect on castor seeds spot price volatility. She infers that the castor seeds futures market has a beneficial on its spot market.

Sahi (2007) concludes that agri-futures trading has a destabilizing effect on spot market volatility. Nath and Lingreddy (2008) explore urad, gram and wheat futures market to analyze their inflationary effect using t-test, linear regression, and Granger causality tests. The t-test results report an increase in average price level and standard deviation (volatility) after introduction of futures trading for the select commodities. The linear regression results show a significant impact of futures trading on the spot price of urad only. Also, they concluded that futures trading Granger cause spot price in case of urad but the inflationary role of futures trading could not be proved.

Sen (2008) studies the impact of futures trading on agricultural commodity prices. He studies both monthly and weekly data on a total of 21 commodities (form 98% of share in total agricultural commodities futures trade). He reports that "the annual trend growth rate in prices is higher in the post-futures period in 14 of these commodities viz. chana, pepper, jeera, urad, chillies, wheat, sugar, tur, raw cotton, rubber, cardamom, maize, raw jute and rice); and lower in 7 commodities viz. soy oil, soy bean, rapeseed /mustard seed, potato, turmeric, castor seed, and gur". He further explains that such a behaviour possibly could be due to reversion to a relatively normal level of inflation as compared to pre-futures unusually high or low inflation in case of 16 out of 21 commodities. He concluded that "the Committee has been unable to determine any conclusive causal relationship (between futures trading and inflation) given the short period during which futures markets have functioned and the complexities that arise because a large number of variables impact spot prices."

Another study conducted by IIM Bangalore (2008) reports that the increase in commodity prices after the introduction of futures is mainly due to the change in market forces and government policies. They don't find any evidence of the inflationary effect of commodity futures trading.

Bose (2007) suggests that futures trading cannot be held responsible for aggravating inflation in India, and hence the ban on trading of commodities like wheat, urad, rice and tur (in 2007) could not be justified. Sahoo and Kumar (2009) investigate the impact of CTT proposed by GoI in the union budget of 2008-09 and nexus between price rise and commodity futures trading for a sample of five commodities for a period of May 1, 2006, to April 30, 2008.

Using three equation structured model framework, they find that an increase in transaction cost or bid-ask spread (taken as a proxy for CTT) would lead to decreased trading activity and increased volatility. Using Granger causality test, they conclude that "out of five select commodities (crude oil, gold, soya oil, copper and chana), trading volume does not Granger cause spot price in all except crude oil. However, the futures price is found to Granger cause spot price for all the five commodities and futures markets are efficient." Hence, no material evidence of futures trading causing inflation could be established.

Ghosh (2010b) analyses the effect of wheat futures trading on physical market price volatility for the sample period of his study is from May 21, 2009, to March 4, 2010. He does not get any evidence of futures trading affecting physical market price volatility.

Sen and Paul (2010) report Granger causality running from futures to spot prices and increase in prices of most of the food items. They don't find any evidence of the reduction of food prices volatility on account of futures trading. They mention that 'financialisation of the commodity market' as the main reason for the hike in commodity prices.

RBI (2010) report finds no evidence of the inflationary impact of agro-commodity futures on agricultural commodity spot prices. The report tells even after the ban on futures trading, the prices of banned commodities continued to rise. Moreover, other commodities like milk and fruits (which were not traded in the futures market) also experienced a rise in prices. The report suggests that the rise in commodity prices in India may be due to being other factors like demand-supply gap, price fluctuations in the international market of these commodities and import dependence.

Irwin and Sanders (2012) suggest that the increase in uncertainty in the commodity market over the last decade has resulted in an upsurge in futures trading volume. They conclude that increasing market participation may be responsible for a decrease in price volatility and an increase in commodity market integration with financial markets.

Sehgal et al. (2012) investigate the effect of futures trading volume on spot price volatility for argi-commodities. They employ GARCH (1,1) model, Granger causality test and Hodrick Prescott filter approach on sample period April 2004 to March 2012. Their results indicate that in the case of five out of seven argi-commodities, unexpected futures trading volume destabilizing effect on spot price volatility, i.e., the former Granger causes the latter.

However, reserve causality effect is seen in the case of black pepper while no causality in either direction is found in the case of barley.

Nair and Eapen (2012) investigate the reasons behind the rise in food commodity prices from January 2008 to June 2010 in India. They suggest that a decrease in supply due to fall in production as the main factor of price rise for most of the commodities. In the case of other commodities, they identify factors like increase in input cost, higher minimum support price, piling up of inventory at govt. depots, unreliable rainfallin2009-10 and costly imports for the rise in food price.

Deloitte (2013) report that "the premise that volatility in spot prices of commodities is attributable to the commodity futures markets is at best tenuous, while in fact, it would appear that commodity futures market has a role in price stabilization. Inflation in agricultural commodities is mainly caused by increasing population, the higher purchasing power of this fuelling population, logistical constraints and market imperfections".

Bohl and Stephan (2013) analyse the influence of futures speculation on spot market volatility for a sample period of twenty years divided into two sub-periods. They do not find any substantial evidence that futures speculation is responsible for making spot markets more volatile.

Gupta and Ravi (2013) analyse the effect of commodity spot prices on WPI inflation for chana, gaur seed, wheat, potato and cottonseed oil cake traded at NCDEX. Using air wise Granger Causality test, Black Exogenity Wald Test and Generalized Impulse Response Function, they find that spot prices of Chana, Guar seed and Wheat are responsible for WPI Inflation while potato and cottonseed oil cake don't have a significant causal relationship with WPI inflation.

Kakati (2014) studies the inflationary impact of the futures market in India. She investigates 20 commodities (15 agro and five non-agro commodities) from 2003 to 2010. She employs GARCH (1, 1), linear switching regression models and structured equation modeling. From GARCH model results, they report that "the impact of old news on yesterday's variance and the level of persistence in the information effect on volatility has been high for 14 commodities" in the transition period (just after futures introduction) or post – futures period. She also reports that the absence of structural changes in the return patterns and a decrease in systematic risk in the post-futures period. She does not get adequate evidence of the spillover effect of agricultural futures prices on WPI.

Rajib (2015) takes expert opinion of Mr. S. Siva Kumar, Divisional Chief Executive, Agri-Business Division, ITC. Mr. Siva Kumar explains the influence of commodity futures trading on spot market volatility. He says "Due to the increasing integration of Indian commodity market with international markets, commodity prices in the Indian market are now not only determined by domestic demand and supply but also by global consumption and production, weather conditions, foreign exchange and freight rates, import and export tariffs, and other government policies." He further adds "Derivative markets smoothen the price volatility compared to a situation where the physical markets operate in isolation."

Ahmad and Sehgal (2015) examine the destabilizing effect of agri-futures on spot market volatility. They study eight commodity futures traded on NCDEX for almost four-year data on daily volume and spot prices. They use the EGARCH model to study spot market volatility, linear Granger causality test and Diks & Panchenko non-linear causality test for causality direction. They also use Hodrick and Prescott, Baxter and King, and Christiano and Fitzgerald filters to study expected liquidity. They report a destabilizing effect of three out of eight commodities (chana, pepper, and chilli).

Lakshmi et al. (2015) find mixed results. For crude oil, they don't find any causality from futures trading volume to spot returns while they report a two-way causality between futures trading volume and spot return in case of gold. Jégourel and Verdié (2015) study the nexus among futures trading, speculation and destabilization effect on the spot market. They report that these markets help in price risk management and information transmission. They suggest speculation in commodity futures market alone is not responsible for the increase in commodity prices.

Gupta and Varma (2016) examine futures trading's effect on rubber spot markets for the pre-ban and the post-ban periods. Using cointegration approach and ECM model, they report that the rubber futures market plays price discovery role for both the sub-periods. Their results indicate the presence of two-way causality for both the sub-periods. Sharma (2016) report that spot returns volatility bears a positive relationship with both unexpected trading volume and unexpected open interest. In other words, futures trading has a destabilizing impact on spot market volatility.

Zavaleta-Vázquez and Arenas (2016) analyse the influence of futures trading on spot price return volatility in Latin American. Using the GARCH model, they report that the futures trading leads to a drop in spot price return volatility of 3 out of 6 commodities.

2.5 Literature Review on International Linkages

The stock market international linkage has been a topic of interest of a number of researchers over decades all over the globe. A huge literature is available on stock market integration. Eun and Shim (1989), Jeon and Von-Furstenberg (1990), Arshanapalli and Doukas (1993), Koutmos and Booth (1995), Ammer and Mei (1996), Chen et al. (2002), Yang et al. (2003), Phylaktis and Ravazzolo (2005), Wong et al.(2005), Bhaduri and Samuel (2009), Bhargava & Dania (2010), Fedorova and Saleem (2010), Joshi (2011), Kumar and Pandey (2011), Padhi and Lagesh (2012), Dhanaraj and Gopalaswamy (2013), Bouri and Yahchouchi (2014), Das (2016), Thakolsri et al. (2016), Mitra and Iyer (2017), Bissoondoyal-Bheenick et al. (2017) are a few of them. Comparatively, research on commodity futures market international integration started late. This section presents available literature on international linkage of stock markets as well as commodities markets across borders.

Eun and Shim (1989) examine the linkage across nine major stock markets from 1980 to 1985. They report significant linkage among national stock markets. They find that 26% variation in national markets is explained by foreign markets, the US market being the most influential. European and Asian-Pacific markets strongly respond to the US market shocks with one day lag and the response is completed within two days. From results, they infer that the international stock market is efficient.

Booth and Ciner (1997) study information flow between Chicago Board of Trade (CBOT) and TGE for corn futures. They analyze price and volatility spillover using two and half year daily open and close prices. They report information transmission from CBOT to TGE, resulting in price determination at TGE.

Booth et al. (1998) investigate the linkage between the CBOT and the Winnipeg Commodities Exchange (WCE), Canada for wheat futures markets. They report that the two markets are cointegrated, i.e., they bear long-run equilibrium. But, they don't find any evidence of such a relationship in the short run. The results of Granger causality test show a causality running from the US market to the Canadian market during the whole sample period as well as two sub-periods, i.e., 1980 to1986, and 1987 to 1994.

Low, Muthuswamy, and Webb (1999) report lack of cointegration and arbitrage between two Asian exchanges namely Tokyo Grain Exchange (TGE) and Manila International Futures Exchange (MIFE). Lin and Tamvakis (2001) investigate the spillover effect between NYMEX, USA and IPE, London for crude oil futures. They use three and a half years of daily log returns data. Using Granger causality and superexogeneity tests, they conclude that the returns of NYMEX effect next morning returns of IPE. Also, they find bidirectional volatility spillover between the two markets.

Holder, Pace and Tomas III (2002) analyse the integration between CBOT, USA and TGE and KCE (Kanmon Commodity Exchange), Japan for Corn and Soybean futures contracts. They report the presence of a complementary relationship between the two contracts.

Yang et al. (2003) analyse price and volatility transmission among the US (CBOT), Canada (Winnipeg Commodity Exchange) and the European Union (London International Financial Futures Exchange) for wheat futures. They apply BEKK-GARCH model, variance decomposition and impulse response function over six-year data. The price spillover results indicate that Canadian prices are more affected by US prices whereas the EU market is independent. However, the volatility spillover analysis shows that transmission takes place from Canada and EU markets to US markets.

Fung, Leung, and Xu (2003) investigate information transmission between US and Chinese futures markets for copper, soybeans, and wheat. They report that the US futures market acts as the main information transmission center for the Chinese market for copper and soybeans. However, the two markets are not found to be integrated for wheat.

Xu and Fung (2005) examined US and Japan futures markets of precious metals like silver, gold, and platinum for cross-linkage using bivariate GARCH and seemingly unrelated regression models. Their results suggest that there is rapid information flow across the two markets, US market playing a leading role. They also conclude from volatility analysis that both the markets have a similar effect on the other market.

Viju et al. (2006) study price linkages in European agricultural markets (Austria, Sweden, Finland, and German) for rye, soft wheat, barley, oats, and potato. The results indicate that the prices of rye, soft wheat, barley, and oats show cointegration after the three countries Austria, Sweden, Finland joined the EU. Also, out of four commodities, rye and barley markets are found to be strongly linked with the EU (German) market.

Hua and Chen (2007) study international linkage between Chinese futures markets at Shanghai Futures Exchange (SHFE), Dalian Commodity Exchange (DCE) and Zhengzhou Commodity Exchange (ZCE) and their world counter parts markets at LME, London and CBOT, USA. They study linkage between SHFE and LME for copper & aluminium and between CBOT and DCE (or ZCE) for soybean (or wheat) for daily prices series over the period 1998 to 2002. The results of Johansen's cointegration report that the US and Chinese markets are cointegrated for all the selected commodities except wheat. Also, they conclude that the London Metal Exchange and the Chicago Board of Trade have a stronger effect on Shanghai copper and aluminium futures, and Dalian soybean futures respectively. The results of Granger causality test report a two-way causality between DCE and CBOT for soybean futures. The results of the impulse response function indicate that CBOT news or shocks have a more significant impact on DCE than vice-versa. Similarly, for copper and aluminium, there is two-way causality between LME and SHFE, but the impact of LME on SHFE is greater than the impact of SHFE on LME for aluminium.

Chongfeng (2007) examines the efficiency and international linkage of the Chinese futures market for copper, aluminium, rubber, soybean, and wheat. He finds Chinese futures markets at SHFE, DCE and CZCE are efficient and dominated by domestic signals.

Lien and Yang (2009) analyse the five-minute returns and volatility spillovers of copper futures contracts across LME, London, NYME, New York and SHFE, Shanghai. They employ a dynamic conditional correlation GARCH model to examine spillover effects. Their results indicate two-way return and volatility spillovers between LME &electronic NYME, and between LME and SHFE while unidirectional volatility spillovers from SHFE to NYME. They conclude that a greater degree of market integration renders faster information transmission across the markets.

Li and Zhang (2009) analyse the long run relationships between the copper futures market at Shanghai Futures Exchange (SHFE) and London Metals Exchange (LME) for a sample period of 2000 to 2006. Cointegration results indicate that SHFE and LME copper futures markets are cointegrated. Their results of the Markov switching model show that there are three regimes with varying intercept and variance which best describes the data. They infer that the impact of LME on SFE is relatively stronger.

Kao and Wan (2009) investigate information flow between four markets of USA (NYMEX) and UK (ICE) natural gas spot and futures prices using daily closing prices over a sample period of 1998 to2007. From Johansen’s cointegration and Hasbrouck Model results, they report that there is efficient information dissemination among the selected markets, US futures market dominating the price discovery. They conclude that these spot markets are less efficient than their respective futures markets. The results of VECM and EGARCH models report that US futures markets are informationally more efficient than UK futures market.

Bhaduri and Samuel (2009) study integration of the Indian equity market with other Asian and developed markets of the world. They report that the Indian equity market's degree of integration has been slowly increasing with these markets since the post-Asian crisis.

Fedorova and Saleem (2010) investigate the relationship between European and Russian equity markets; between the currency markets of the Czech Republic, Poland, Russia and Hungary; and the interdependence between these equity and currency markets for a sample period of 1995 to 2008. They report "evidence of direct linkages between the equity markets in terms of both returns and volatility, as well as in the currency markets." Also, they find one-way volatility transmission from currency to stock markets. They conclude that Eastern European markets are integrated within Europe as well as with Russia.

Ge et al. (2010) analyse integration between Intercontinental Exchange, US and Zhengzhou Commodity Exchange, China futures market for weekly price series of cotton over four years. The results of their study indicate that the two markets are cointegrated and show two-way causality. They also conclude that the two series exhibit ARCH/GARCH effects.

Eissa et al. (2010) analyse volatility transmission between nominal exchange rates and stock returns from 2001 to 2007. Their results of MGARCH model indicate that there is no return spillover across the markets while there is evidence of two-way volatility transmission between exchange rates and stock returns. Their results are more prominent in Egypt and Turkey. They suggested that the difference in results is because of different exchange rate policies followed by these economies.

Wang (2011) reports that soybean and rapeseed markets in China bear a long-run equilibrium relationship with international markets. However, bidirectional causality relationship exists between the two markets for soybean only. The oil markets of soybean and rapeseed in China and outside are found to be entirely independently of each other.

Aruga and Managi (2011) analyse international linkage of Japanese precious metals (gold and silver) futures markets with US markets using the law of one price and structural break approach. Using Johansen cointegration test, they conclude there is no cointegration between US and Japanese precious metal markets. However, they find that cross-commodity linkage. Also, they find that the law of one price does not hold without structural break consideration but holds during some period under structural breaks. They also report that US price plays a significant role in cointegration relationship between the US and Japanese prices.

Liu and An (2011) examine copper and soybean markets of the US and China for information flow and price discovery for the sample period 2004 to 2009. Using Johansen's cointegration, multivariate VECM- GARCH and Information share framework, they report the two-way flow of information between US markets (NYMEX, CBOT, and CME Globex futures market) and Chinese markets (SHFE copper futures market and DCE soybean futures market). They suggest that NYMEX and CBOT play a more crucial role than CME Globex in price discovery in Chinese markets. They conclude that price discovery takes place US futures markets followed by Chinese futures market and then the Chinese spot market.

Kumar and Pandey (2011) study linkages between the Indian commodity futures market at NCDEX and MCX, and other world markets at CBOT, NYMEX and LME. They study nine commodities including agro-commodities, precious metals, non-precious metals, and energy commodities. They apply Johansen cointegration test, weak exogeneity test, VECM model and Granger causality test on daily futures log returns. They find that Indian commodity futures markets bear a long-run relationship with its world counterparts for the select commodities. The study also finds that world markets Granger cause Indian commodity futures market. Moreover, their results of volatility spillover are also similar to return results. They conclude that Indian commodity futures markets are integrated with world markets.

Bhargava and Dania (2012) in their study on inferring that there is no effect of world equity markets on equity markets returns in SAARC countries. However, they find volatility transmission from world equity markets to markets in India, Sri Lanka and Bangladesh.

Fung et al. (2013) explore the relationship between Chinese and foreign futures markets like the USA, the UK, Malaysia, and Japan for sixteen commodities. They report that daily close price returns and daytime returns of Chinese and foreign markets have no causality relationship. However, China's overnight returns are affected by US market trading returns. They further suggested that the Chinese commodity futures markets are information-efficient.

Dhanaraj et al. (2013) conclude that US stock market dominates Asian markets. They further conclude that a major crisis like the Asian crisis and sub-prime crisis can affect the relationship among stock markets. Rutledge et al. (2013) analyze linkage and information flow among copper futures market at LME, SHFE, and NYMEX-COMEX. They report that LME and COMEX show highly correlated overnight returns while SHFE is relatively more independent or less correlated with the other two markets. Further, they find that these markets exhibit long-run equilibrium and can be considered at a single market. Their results indicate that two-way causality between all these markets, LME to SHFE and COMEX to SHFE markets causality being the most significant.

Bouri and Azzi (2014) find evidence of volatility linkage across Middle East and North African (MENA) equity markets creating a possibility of risk diversification. Further, they report that market volatility is more governed by its own shocks than cross shocks from other markets. They conclude that there is substantial volatility transmission from small to larger markets.

Bouri and Yahchouchi (2014) investigate the dynamic return and volatility relationship across MENA stock markets and the effect of the GFC of 2008. Their results indicate that volatility linkage among MENA markets. They report an increase in conditional volatilities across markets rises in the crisis period. However, they report the dynamic behavior of conditional correlation across the select markets.

Fuangkasem et al. (2014) investigate information flow among NYMEX –COMEX of USA, MCX of India and TOCOM of Japan for the gold futures market. They use five months high-frequency synchronous trading data. They get evidence that these markets are cointegrated and a lead-lag relationship exists among them. COMEX gold futures market is found to play a dominant role in price discovery.

Das (2016) analyses the linkage of the Bombay Stock Exchange (BSE) Sensex returns with its world counterpart markets. He finds a linear relationship between the select markets. They report that "the upper and lower tail strong dependencies of the BSE with Nikkei and Hang Seng. The VAR results indicate that BSE weekly returns are influenced by two lags of the Hong Kong stock market (HANG) while the NIKKEI and the SHANG are influenced by up to 1 week and two-week lags of the BSE, respectively." The results of GARCH (1, 1) model report that Nikkei market is much more volatility than other markets, while the BSE market is moderately volatile.

Bissoondoyal-Bheenick et al. (2017) study volatility spillover among the US, China, and Australia stock markets. The sample data comprises of intraday prices (every 5 minutes) on CSI300, China; ASX200, Australia and S&P500 index, the US from 2007 to 2016. They use fractional integration VAR. Their study considers the S&P500 index to control the effect of the US market on the other two markets. They report bidirectional causality among the three markets across many industries. They find that there is unidirectional volatility transmission from the US to China in some industries like financial services, consumer discretionary and utilities. On removing the effect of GFC, they report significant two-way association across the select industries and countries. To check the global financial crisis's effect, they study the robustness of results for the sub-period 2009 to 2016.

2.6. Literature Review on Global Financial Crisis and Commodity Market Volatility

The recent global financial crisis had sucked liquidity and spiked volatility in markets along with weak economic scenario. The equity markets were hit the worst with approx. 60 % fall in the market index during the crisis period. This seems to be the reason for plethora of the available studies on the effect of the recent GFC on the stock market. Some of these studies are Olowe (2009), Sheikh (2010), Adamu (2010) Ravichandran and Maloain (2010), Dufrénot et al. (2011), Verma and Mahajan (2012), Singh (2012) and Kishor and Singh (2014).

As far as the effect of the recent GFC on commodity market is concerned, there is a shortage of research. Olowe (2010) analyze the impact of the global financial crisis 2008 and Asian financial crisis 1997 on oil price return volatility. They find properties like volatility clustering and volatility persistence. However, the leverage effect was observed to be absent. They also concluded that the recent GFC did not affect the volatility of crude oil price returns.

Using the Fractionally Integrated GARCH (FIGARCH) model, Arouri et al. (2012) report long term dependence in the daily conditional return and volatility processes for the select metals. They infer that gold is a better investment tool than platinum during the crisis. Ismail et al. (2012) analyse the effect of the crisis on the volatility of select metals. Using the GARCH model, gold and platinum are safer investment avenue as compared to Silver and Bronze.

Bialkowski et al. (2014) investigate the possibility of a new asset price bubble due to hastily rising investment activities. They employ variance-inflation tests, regression, and Markov regime-switching ADF test. They report that one need not take recourse to the irrational bubble justification to explain the substantial fluctuations witnessed in the gold market. Using a modified ARMA and GARCH model, Sinha and Mathur (2016) conclude that the GFC and the equity market's implied volatility affect the gold futures market.

2.7. Research Gap

From the extensive literature review, some research gaps have been identified. These gaps have been presented below. Firstly, available studies on the commodity futures market efficiency are focussed primarily on developed countries. Few studies have been conducted in the commodity futures market in India, but their findings have often been conflicting. The EMH is accepted only for some commodities over some periods. Moreover, the study of commodity futures markets' efficiency is imperative to the different stakeholders like traders, manufacturers or processors, farmers, policy makers, government, etc. in India. An efficient market provides a superior option to market interferences by the government and a dependable estimate of future spot prices. So a further investigation on efficiency is required in the commodity futures market in India given the importance of an efficient market to render price discovery and price risk management.

Secondly, the most relevant aspect for agro-commodities, although not yet extensively investigated, is seasonality. Seasonality is an important price determinant of commodities and may interfere with futures market efficiency. Moreover, there is no Indian study on the effect of seasonality on futures market efficiency. Since India is one of the biggest consumer and producer of several agri-commodities, there is scope for such a study in India.

Thirdly, inflation is a matter of national and global concern to the governments. There is a strong popular belief that speculators are responsible for the increase in commodity prices though they bring liquidity and price stability in the market. In India, there have been allegations on commodity futures trading of inflationary impact. Following the suggestions of India's parliamentary standing committee and increasing pressure from political circles, the GoI banned futures trading on some essential agro-commodities like wheat, rice and two varieties of lentils. Also, GoI temporarily suspended futures trading in commodities like chana (chick pea), soyoil, rubber, and potato. Moreover, the Abhijit Sen committee failed to find sufficient evidence of the inflationary effect of agricultural futures trading on prices of agri-commodities. Also, the literature presents conflicting findings varying from stabilizing effect (Sahoo and Kumar, 2009; Bose, 2007; Nair and Eapen, 2012; Deloitte, 2013; Rajib, 2015 etc.) to destabilizing effect (Sahi, 2007; Sehgal et al., 2012 and Sharma, 2016) to mixed effect (Gupta and Ravi, 2013; Ahmad and Sehgal, 2015; Lakshmi et al., 2015 and Gupta and Varma, 2016) of futures trading on spot market volatility and inflation. Thus, further empirical investigation is required.

Fourthly, there is a shortage of studies on international integration of Indian commodity market and the effect of the recent GFC on the commodity spot market. Commodities are being used as an asset class generating greater risk-adjusted returns in comparison to capital markets (Domanski and Heath, 2007). At the same time, commodity trading has become much more volatile due to market integration. Studies like Slade and Thille (2004), Yang et al. (2005), Nath and Lingareddy (2008) find that commodity trading has led to an increase in volatility. Rising commodity prices all over the globe and in India in the last few years have raised a question on the performance of commodity spot and derivatives markets (Kumar et al., 2010). Thus, it becomes important to investigate these issues for Indian commodity markets. This study is an attempt to address the above-mentioned aspects of the commodity market and try to fill the research gap.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Introduction

Chapter 2 discusses various econometric techniques that have been used in literature to test the different aspects like the efficiency of the commodity futures market, inflationary impact of commodity futures trading, seasonality effect on commodity futures market efficiency, etc. Over time, the research methodology for efficiency analysis has evolved from regression to cointegration technique. Studies like Maberly (1985) and Shen and Wang (1990) used simple linear regression while William et al. (1998) and Durham and Si (1999) described the efficiency on the basis of arbitrage and law of one price. After the introduction of cointegration technique by Engle and Grange (1987), many authors like Aulton, Ennew, and Rayner (1997), Singh (2004), Dimitris and Aristeidis (2004), Liu (2005) and many others used cointegration to test efficiency.

Further, Johansen (1988, 1991) and Johansen and Juselius (1990) introduced the maximum likelihood method for cointegration analysis. Lai and Lai (1991) advocated Johansen's cointegration method to analyse market efficiency. Using Johansen's cointegration, Randall and Zapata (1993), Mckenzie and Holt (1998), Kellard, et al. (1999), Wang and Ke (2005), Bhar and Hamori (2006), Switzer and El-Khoury (2006), Xin, Chen and Firth (2006), Singh (2007), Ali and Gupta (2011), Arora and Kumar (2013), Peri et al. (2013), Malhotra and Sharma (2016) etc. tested the efficiency of the commodity futures market. Similarly, research methodology has evolved in analysing other important aspects of the commodity futures market. This chapter throws light on the data and methodology that has been used in this study.

3.2. Data and Sample

The period of this study begins from the year of commencement of futures trading in the select commodities on MCX / NCDEX, India. Chana futures trading began on NCDEX in 2004, while gold, crude oil and copper futures trading started in 2005 on MCX. Accordingly, data were collected from the date the spot prices became available on these exchanges until 2017 (except chana due to ban on its futures trading in 2016). The present study spans from

2004 to 2017. The selected commodities (gold, crude oil, copper and chana or chick pea) are the top weighted commodities (in Comdex) of their own category collectively accounting for more than 60% weight in Comdex-the commodity index of MCX (see Table 3.1). Table 3.2 shows the details on the data period, the number of observations, and the commodity market.

Table 3.1: MCX COMDEX 2014 (May) Composition

MCX COMDEX	Type of Commodity	Commodity	Weight (New)	Group Adjusted Weights
MCX METAL INDEX	Precious Metal	***Gold***	**15.21%**	
	Precious Metal	Silver	9.66%	
	Non- Precious /Base Metal	***Copper***	**7.13%**	
	Base Metal	Zinc	2.00%	
	Base Metal	Aluminium	2.00%	
	Base Metal	Nickel	2.00%	
	Base Metal	Lead	2.00%	**40.00%**
MCX ENERGY INDEX	Energy	***Crude Oil***	**35.41%**	
	Energy	Natural Gas	4.59%	**40.00%**
MCX AGRI INDEX	Agro	Ref. Soy Oil	3.91%	**20.00%**
	Agro	*Potato*	4.76%	
	Agro	***Chana***	**4.14%**	
	Agro	Crude Palm Oil	3.19%	
	Agro	Kapaskhalli	2.00%	
	Agro	Mentha Oil	2.00%	

3.3. Research Tools and Techniques

The objectives of this study warrant the use of quantitative and causal research methodology employing secondary data. According to Kothari (2004) “Quantitative research is based on the measurement of quantity or amount”. In other words, it is limited to what can be measured or quantified (Winter, 2000). According to *Ghauri and Gronhaug (1995)*, "the causal research is used when the problems are under structured."

Table 3.2: Commodity Market and Period of Sample Data

Comm -odity	**Type of Commo -dity**	**Market**		**Period**		**Number of observations**
		Spot Market	**Futures Market**	**From**	**To**	
Gold	Precious Metal	Ahmedabad	MCX	6th June 2005	31st March 2017	3,325
Crude Oil	Energy	Mumbai	MCX	16thMay 2005	31th March 2017	3,444
Copper	Non – Precious Metal	Mumbai	MCX	1st July 2005	31th March 2017	3,363
Chana	Agro	Delhi	NCDEX	21th May 2004	20th July 2016	3423

This study makes use of MS Excel (for descriptive statistics, and graphical analysis) and Eviews 8.0 (for econometric modeling and analysis) to process and analyze data. Descriptive statistics and graphical tools have been used to present the time series data. To test efficiency, seasonality, inflationary impact, international linkage, and volatility analysis, the following research techniques have been applied.

3.3.1. Preliminary Analysis

Before analyzing the variables for a particular research objective, it is important to conduct the preliminary analysis. In this study, the preliminary analysis includes summary statistics and testing for outliers and testing the unit root properties.

3.3.1.1. Summary Statistics and Testing For Outliers

Summary statistics are done to study the statistical properties of the data. Also, it is useful to test the suitability of the data for further statistical or econometric analysis. It is suggested to identify and remove outliers if any. This is done by plotting a scatter diagram of the raw data. Summary statistics gives necessary information on statistics like mean, median, mode, kurtosis, skewness, and distribution of data.

3.3.1.2. Unit Root Tests

Unit root (or stationarity) tests are employed to study stationarity properties of a time series. The mean, variance and autocovariance (at various lags) of a stationary series do not change with time. A given time series is expected to be non-stationary at levels and stationary on differencing. A series which is the first-differencing stationary is known as an integrated series of the first order, i.e., *I(1).*

Out of the different stationarity tests, this study uses the following tests.

a) Graphical Analysis
b) Augmented Dickey-Fuller (ADF) Test
c) Phillips Perron (PP) Test

The graphical method is a quick and crude method of testing stationarity of a sample series. If the prices (y-axis) are varying with time (x-axis) showing an upward or downward trend, the series would be called non-stationary.

The second method, the ADF test is conducted by augmenting the DF test. It is most widely used unit root test (Chowdhury, 1991; Lai and Lai, 1991; Mckenzie and Holt, 1998; Wang and Ke 2002; Yang et al., 2005; Bohl and Stephan, 2013; Ahmad and Sehgal, 2015; Gupta and Varma, 2016). The regression equation of the ADF test is

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-1} + \varepsilon_t \qquad (3.1)$$

Under the null hypothesis (H_o), the given series is assumed to be unit root (non-stationary). The rejection of H_o implies that the series is stationary at level.

The third method, PP is also a non-stationarity test. Like the ADF test, this test has a non-stationarity assumption under the null hypothesis. Thus, in case of a non-stationary series, the null hypothesis is not rejected.

3.3.2. Methodology for Analysing Efficiency

This study analyses the weak form efficiency of commodity futures market as this is the most widely tested hypothesis. According to the Expectation Hypothesis, “a futures market is defined as efficient if the current futures price (*t=0*) of a futures contract of maturity *t* provides an unbiased estimate of the futures spot price at time t.” The futures price is contemplated to be an unbiased forecast of the future spot price, i.e., the spot price at contract maturity (Kellard et al., 1999; Haigh, 2000). In an efficient market, spot and futures prices are cointegrated, and futures price leads spot price (Sahoo and Kumar, 2009).

From literature, it is found that different econometric techniques have been used by different researchers to analyse the efficiency of commodity futures market from time to time. With time the research methods have evolved. These are simple linear regression model**,** the law of one price model, the co-integration methodology and Johansen's Co-integration methodology. This study examines the commodity markets efficiency through price discovery mechanism by conducting cointegration and causality analysis between future and spot prices. This study uses Johansen's cointegration technique to investigate cointegration between the futures and spot price series, and Granger Causality to analyse causality between the futures and spot price series.

3.3.2.1. Testing for Cointegration- Johansen's Cointegration

A linear combination of I(1) variables is I(0) if the variables are cointegrated. In economic terms, cointegrating variables bear an equilibrium relationship with one another. In the short run, they may drift apart from their relationship.

Let S_t be the spot price and F_{t-i} be futures price at time *t* and *t-i* respectively, where *i* is the time to maturity. The cointegration between these prices is a necessary condition for market efficiency (Lai and Lai, 1991). Out of the various cointegration techniques, Johansen's Co-integration method has been extensively used in the literature (Lai & Lai, 1991; Randall and Zapata, 1993; Mckenzie & Holt, 2002; Wang & Ke, 2005, Ali & Gupta, 2011; Arora and Kumar, 2013). This study employs Johansen's Co-integration methodology to analyse the efficiency of futures markets of the select commodities.

Johansen's cointegration technique based on two variables VAR model having k lags is shown below:

$$\Delta Y_t = \mu + \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t \quad . \quad . \quad . \quad . \quad (3.2)$$

where

Y_t= vector to be tested for cointegration

$\Delta Y_t = Y_t - Y_{t-1}$

μ= deterministic term and

Π and Γ= matrices of coefficients

Johansen test uses two test statistics to test cointegration. These are λ_{trace} or trace statistics and λ_{max} or max eigen value statistics. For both of these statistics, the null hypothesis is tested for r = 0 and r = 1 for the given two series, i.e., futures and spot prices. If r = 0 cannot be rejected, then the given series are said to have no cointegration vector, and therefore, no cointegration. However, if r = 0 is rejected, and r = 1 cannot be rejected, then the given series have a cointegrating relationship. In case of any conflict in the results of λ_{trace} and λ_{max}statistics, one should prefer trace statistics (Johansen and Juselius, 1990). This study assumes that the data has a linear deterministic trend. The given series are expected to bear a long-run relationship.

3.3.2.2. Testing for Causality- Granger Causality

After examining the cointegrating relationship, it is important to employ a causality test to analyse the direction of causality (Malliaris and Urrutia, 1998; Bryant et al., 2006). Granger causality technique is commonly employed to know the direction of causality (Sahoo and Kumar, 2009; Arora and Kumar, 2013; Ali and Gupta, 2011). According to Brooks (2008), causality tests aim to answer the question; "Do changes in x causes changes in y?" x is said to Granger-cause y if the lags of x are significant in the equation for y. Granger causality technique can be shown as a k^{th} order VAR as given under:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i \, Y_{t-i} + \sum_{j=1}^{k} \beta_j \, X_{t-j} + \in_t \tag{3.3}$$

$$X_t = \gamma_0 + \sum_{i=1}^{k} \gamma_i \, X_{t-i} + \sum_{j=1}^{k} \delta_j \, Y_{t-j} + \in'_t \tag{3.4}$$

Where X_t and Y_t are spot and futures price series, α_0 and γ_0 are constant drift terms, and $\in_t$ and $\in'_t$ are error terms. The causality is said to be one-way if the lags of *y (or x)* are significant in the equation of *x (or y).* There is bi-directional causality when both *x* and *y* Granger cause each other.

Here, the null hypothesis that $\beta_1 = \beta_2 = \cdots = \beta_k = 0$ in equation (3.3) has been tested using F-test. Similarly, the null hypothesis that $\delta_1 = \delta_2 = \cdots = \delta_k = 0$ in equation (3.4) has been tested.

Granger causality measures lead and lag relation between two variables. Granger causality test can be employed in two different forms. In the case of no cointegration between given variables, Granger test (Granger, 1969) is employed to examine the short-run relationship. Whereas, VEC Granger Causality/Wald test (Engle and Granger, 1987) is employed if the given series are cointegrated.

3.3.3. Methodology to test Seasonality in Agri-futures Market

3.3.3.1. Ramsay RESET Test

It is crucial to test which functional form of the regression model best fits the data. The results may be misleading if a wrong functional form of the regression model is chosen. Thus, this study employs Ramsay's RESET test to formally test whether the linear form of the regression model fits the data.

Ramsay's RESET test works by regressing y_t on the higher order terms of the fitted values ($\hat{y}_t$) together with the original explanatory variables.

$$y_t = \alpha_1 + \alpha_2 \hat{y}_t^{\,2} + \alpha_3 \hat{y}_t^{\,3} + \ldots\ldots + \alpha_p \hat{y}_t^{\,p} + \sum \beta_i x_{it} + v_t \quad \ldots\ldots\ldots\ldots (3.5)$$

Where

$$\hat{y}_t = \hat{\beta}_1 + \hat{\beta}_2 x_{2t} + \hat{\beta}_3 x_{3t} + \ldots\ldots + \hat{\beta}_k x_{kt} \qquad \ldots\ldots\ldots\ldots (3.6)$$

Higher order powers of $\hat{y}_t$ can capture a variety of non-linear relationships. Under the null hypothesis, the relationship between the select variables is linear. If the null hypothesis is rejected, the variables are said to have a non-linear relationship. This test has been employed taking $dlnSP_t$ as dependent variable and $dlnFP_t$, $dlnFP_{t-1}$ and $dlnFP_{t-2}$ as independent variables in different models.

3.3.3.2. Regression Models (With and Without Dummy)

According to the Expectation Hypothesis, in an efficient futures market, the current futures price (t=0) of a futures contract of maturity t provides an unbiased estimate of the futures spot price at time t. Here, the relationship between the future and spot price series is analysed using the following regression model.

$dlnSP_t = \alpha + \beta \, dlnFP_t + \epsilon_t$ ………..(3.7)

Where

SP_t = the spot price

FP_t = the futures price

$dlnSP_t$ = the first difference of natural logarithm of the spot price.

Similarly, other notations follow.

For futures prices, contracts nearest to maturity are taken into account as amongst the contracts of different maturities, trading volumes are expected to be highest for these contracts (Zhong et al. 2004, Karmakar 2009, Sehgal et al. 2013, Kumar and Arora, 2014). For instance, copper futures contracts expire on the last date of every month. Thus, August month's futures prices have been taken from August futures contract, July month's futures prices have been taken from July futures contract, and so on to make daily futures price series. Similar methodology to construct daily price has been used by Raju and Karande (2003), Gupta and Singh (2007), Karmakar (2009), Chaihetphon and Pavabutr (2010), Narayan, Narayan and Zheng (2010), Kumar and Arora (2011), Ali and Gupta (2011), Kumar and Pandey (2013), Arora and Kumar (2013), Chhatwal and Puri (2013), Sehgal et al. (2014), Soni (2014) and Sinha and Mathur (2016).

The seasonality pattern of crop depicts the season of its sowing, growing, and harvesting. During this period, the prices of agri-product may be rising subject to the demand and supply forces. But post-harvest, the prices are usually expected to fall. To analyze seasonality, a dummy has been introduced in the regression model shown above as equations 3.8. The modified regression equations are shown below.

$dlnSP_t = \alpha + \beta_1 \, dlnFP_t + \beta_2 \, Dummy + \epsilon_t$ ……….. (3.8)

Where dummy is a binary variable having value 1 for the months of the season of the crop and 0 for off-season months, i.e., the period of sowing. Chana (chickpea) is also a seasonal commodity which is grown in winters in September/October to November and harvested from February to April in India. So, the dummy assumes value 1 for the months of the season of the crop (from March to September) and 0 for off-season months (from October to February).

The null and alternate hypotheses to analyse seasonality effect using regression analysis are as follows.

H_o: There is no effect of seasonality on the spot price, i.e., $\beta_2 = 0$

H_1: There is an effect of seasonality on the spot price, i.e., $\beta_2 \neq 0$

3.3.4. Methodology for Examining Inflationary Impact- Toda Yamamoto Modified Granger Causality Test

This study uses *Toda Yamamoto version of Granger Causality Test* to analyze the inflationary impacts of commodity trading in India for the select commodities and sample period of the study. Granger causality test generally needs pre-testing cointegration. However, one can employ Toda Yamamoto (TY) version of Granger causality irrespective of the cointegrating relationship between the given series and independent of the order of integration. Thus, it is not influenced by the potential bias related to stationarity and cointegration tests (Toda and Yamamoto, 1995).

The prerequisite for conducting causality analysis is testing stationarity of the sample series. This is because to apply Toda Yamamoto (TY) modified Granger causality test; it is required to know the maximum order of integration of the process. For instance, if one series is I(0) while other is I(1), then the maximum order of integration ($d_{\max}$) of the process is taken as 1. According to Toda Yamamoto, "we can apply the usual lag selection procedure as far as the order of integration of the process does not exceed the true lag length of the model." Thus, the unit root test is first conducted on the sample series using ADF and KPSS tests as discussed above in section 3.3.1.2.

TY modified Granger causality test (shown in equation 3.9 and 3.10), like Granger causality, gives the direction of causality. The following VAR system denotes TY modified Granger causality test.

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Y_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} Y_{t-j} + \sum_{i=1}^{k} \beta_{1i} X_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} X_{t-j} + \epsilon_{1t} \quad (3.9)$$

$$X_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} X_{t-i} + \sum_{j=k+1}^{d\max} \gamma_{2j} X_{t-j} + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \sum_{j=k+1}^{d\max} \delta_{2j} Y_{t-j} + \epsilon_{2t} \quad (3.10)$$

Where,

X_t= log series of WPI and

Y_t= log series of futures trading volume

k = the true lag length of VAR system and

d_{max}= the maximum order of integration.

As compared to Granger causality VAR system, the TY VAR system contains d_{max} (maximum order of integration) number of lag terms over and above k (true lag length) lags. Thus, for estimating $(k+d_{max})^{th}$ order VAR, the test follows asymptotic χ^2 distribution (Wolde-Rufael, 2004). According to Toda and Yamamoto (1995), "we can apply usual lag selection procedure as far as the (maximum) order of integration of the process does not exceed the true lag length of the model." Here, Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC) have been used to get the true lag length (*k*).

3.3.5. Methodology for Investigating the Effect of Global Financial Crisis (GFC) on Commodity Spot Market Volatility - EGARCH

This study employs the Exponential Generalized Autoregressive Conditional Heteroscedasticity (*EGARCH*) model with a dummy to analyse the impact of GFC on the spot market volatility of crude oil. The dummy takes value zero for the pre-crisis period (May 3, 2005, to September 14, 2008) and one for the post-crisis period (September 15, 2008, to March 31, 2017).

EGARCH model measures the asymmetric effects of shocks on volatilities. The model has many advantages over the pure GARCH specification. Firstly, this model uses the $\log(\sigma^2_t)$ term rendering σ^2_t term always a positive value, unlike the GARCH model. Secondly, EGARCH formulation allows for asymmetries that are captured by γ sign, i.e., γ will have a positive sign if volatility bears a positive relationship with returns. In other words, the EGARCH model permits negative and positives innovations to act in different ways. The mean and variance equations of EGARCH (1,1,1) model are shown below as equations 3.14 and 3.15.

Mean Equation: $Y_t = c + \mu_t$ (3.11)

Variance Equation: $\ln(\sigma_t^2) = \omega + \alpha\,|\mu_{t-1}/\sigma_{t-1}| + \beta\ln(\sigma_{t-1}^2) + \gamma\,(\mu_{t-1}/\sigma_{t-1})$ (3.12)

In this model, α, β and γ capture ARCH, GARCH and leverage effects respectively. α gauges the influence of volatility news from the previous period on current period volatility and β gauges the influence of the last period's variance. A positive α indicates volatility clustering while γ is expected to be negative.

To study the effect of the recent GFC, the dummy variable is introduced in both equations (1) and (2) as shown below.

$$Y_t = c + \delta_1 D + \mu_t \quad (3.13)$$

$$\ln(\sigma_t^2) = \omega + \alpha\,|\mu_{t-1}/\sigma_{t-1}| + \beta\ln(\sigma_{t-1}^2) + \gamma\,(\mu_{t-1}/\sigma_{t-1}) + \delta_2 D \quad (3.14)$$

Where δ_1 represents a change in Y_t and δ_2 represents a change in volatility due to global financial crisis 2008.

3.3.6. Methodology for Analyzing International Linkages of Indian Commodity Market

3.3.6.1. Johansen's Cointegrated Test

Cointegration is the most popular technique among researchers for studying market linkage (Nazlioglu et al. 2012, Viju et al. 2006, Zhang and Wei 2010, and Low, Muthuswamy, and Webb 1999) and Johansen cointegration is the most widely used technique (Aruga and Managi 2011, Kumar and Pandey 2011, Bhar and Hamori 2006, Ge et al. 2010, Natanelov et al. 2011, Hua and Chen 2007, Chongfeng 2007 and Wang 2011). In this study, the long run equilibrium relationship between the two selected futures markets of crude oil has been analysed using the Johansen cointegration approach. The technique has been discussed in detail in section 3.3.2.1.

3.3.6.2. VEC/VAR Granger Causality Test

Granger causality method has been used in literature by Natanelov et al. (2011), Lin and Tamvakis (2001), Ge et al. (2010), Irwin and Sanders (2011), Ge et al. (2010), Hua and Chen (2007), and Wang (2011). Granger (1969) proposed and described the Granger causality test to analyse lead-lag interaction between given variables. A bi-variate k^{th} order VAR is given as:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \, Y_{t-i} + \sum_{j=1}^{k} \beta_{1j} \, X_{t-j} + U_t \qquad (315)$$

$$X_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} \, X_{t-i} + \sum_{j=1}^{k} \delta_{1j} \, Y_{t-j} + U'_t \qquad (3.16)$$

Where X_t and Y_t are MCX and NYMEX/SHFE logged futures prices time series of select commodity, α_0 and γ_0 are constant drift terms, and U_t and U'_t are error terms respectively. The technique has been discussed in detail in section 3.3.2.2.

CHAPTER 4

EFFICIENCY AND SEASONALITY ANALYSIS

4.1. Introduction

Market efficiency is the most important aspect of the futures market as it facilitates in price discovery in the futures market. Commodity futures market efficiency is vital not only to enable price risk management and price discovery but also to help the government bring in price stabilisation (Sahadevan, 2002; Chakrabarti and Ghosh, 2009). In other words, in an efficient futures market spot and futures prices are cointegrated, and futures price leads spot prices (Sahoo and Kumar, 2009; Arora and Kumar, 2013; Ali and Gupta, 2011). Good amount of literature is available on market efficiency of the futures market in both developed as well as emerging markets. But, the results of research conducted on the efficiency of different markets suggest conflicting findings. The evidence of efficiency has been found in the work of Gupta and Ravi (2013), Sehgal et al. (2012), Ali and Gupta (2011), Chakrabarty and Sarkar (2010), Singh (2010), Lokare (2007), Bose (2007), Gulen (2000) etc. However, inefficiency evidence has been found in the work of Inoue and Hamori (2012), Soni and Singla (2012), Easwaran and Ramasundaram (2008), Wang and Ke (2005), Mckenzie and Holt (2002) and many others while mixed results have been found in the studies of Aulton et al. (1997), MacDonald and Taylor (1988a), Singh (2004) etc. Some of the important researches relating to efficiency have been summarized in chapter 2 section 2.2.

Another vital concern governing the efficiency of the commodity futures market is seasonality. Seasonality is a relatively untouched issue that plays a very important role in agro-commodity pricing. There is a scarcity of research on seasonality in the commodity futures market, especially in the Indian commodity futures market. Some of the important researches relating to efficiency and seasonality have been summarized in Chapter 2 section 2.3. This chapter analyses the efficiency of the select four commodities and the effect of seasonality on the efficiency of agricultural commodity chana (chick pea). This study examines the efficiency in commodity markets through price discovery mechanism by conducting cointegration and causality analysis between future and spot prices. This study uses Johansen’s cointegration technique to analyse cointegration between the futures and spot price series, and Granger Causality to analyse causality between the futures and spot price series.

4.2. Data Analysis – Efficiency

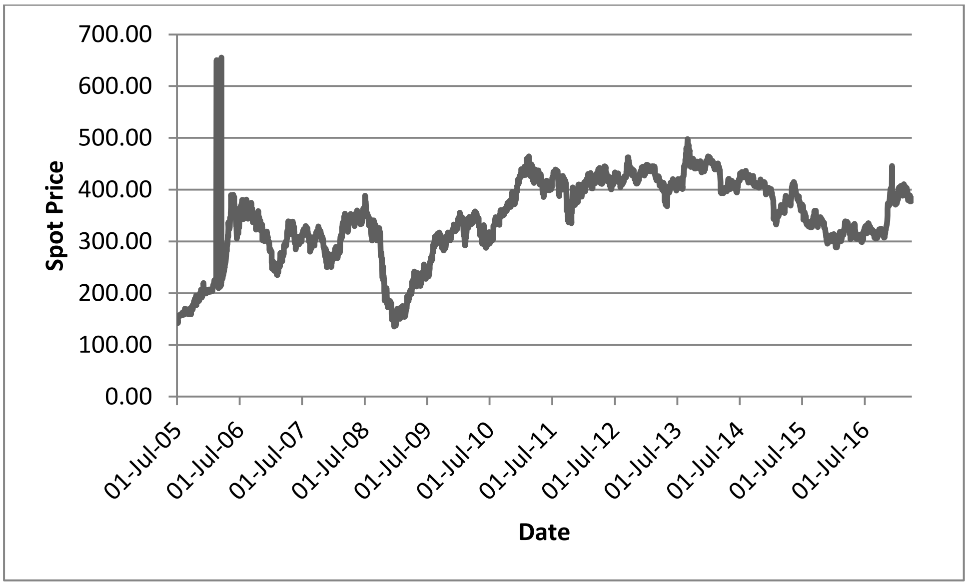
4.2.1. Preliminary Analysis

In this study, the preliminary analysis includes summary statistics, testing for outliers and testing the unit root properties.

4.2.1.1. Summary Statistics and Testing For Outliers

First, the data of spot and futures prices are checked for outliers. This can be done by plotting a scatter diagram or line graph of the data series. Copper spot price series is found to have two outliers corresponding to 16th February 2006 and 16th March 2006. The prices on these dates are found to be as high as Rs 650.50. These outliers can be seen as sharp peaks in Figure 4.1. Thus, these two outliers are removed before proceeding for summary statistics. The other three commodities price series do not contain any outliers.

Figure 4.1: Copper Spot Price Movements



Summary statistics are done to study the statistical properties of the data. It gives basic information on statistics like mean, median, mode, standard deviation, kurtosis, skewness, number of observation and distribution of data using Jarque bera test of normality. Table 4.1 & 4.2 show that the descriptive or summary statistics for log series of spot and futures prices (LNFP and LNSP) and respective log return series (RFP and RSP) of the chana (chick pea), gold, crude oil and copper in the pre and the post-crisis periods respectively.

From Table 4.1 & 4.2, it is shown that the average daily return of all the commodities except chana has decreased in the post-crisis period. The average daily returns on crude oil have fallen drastically from +0.07 in the pre-crisis period to -0.01 in the post-crisis period.

Table 4.1: Descriptive Statistics in Pre-Crisis Period

Commodity	Descriptive	LNFP	LNSP	RFP	RSP
Chana	Mean	7.626805	7.620904	0.040423	0.039393
	Median	7.676937	7.684485	0.000000	0.015765
	Std. Dev.	0.222197	0.228555	1.684862	1.430746
	Skewness	-0.05031	-0.11951	-1.58484	-0.39409
	Kurtosis	1.955135	1.958350	19.17878	8.091331
	Jarque-Bera	55.04730	57.06067	13567.34	1324.932
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	1199	1199	1198	1198
Gold	Mean	9.125839	9.124759	0.064050	0.064932
	Median	9.132271	9.128045	0.070023	0.116620
	Std. Dev.	0.196628	0.195910	1.073286	1.105851
	Skewness	-0.29342	-0.24451	-0.65919	-0.68812
	Kurtosis	2.693300	2.683461	7.508273	6.257192
	Jarque-Bera	17.73911	13.72864	891.6983	505.3423
	Probability	0.000141	0.001044	0.000000	0.000000
	Observations	971	971	970	970
Crude Oil	Mean	8.071944	8.069047	0.074561	0.077951
	Median	7.985144	7.988204	0.082353	0.000000
	Std. Dev.	0.236658	0.240232	1.595333	1.820306
	Skewness	1.116431	1.088415	0.169718	-0.04294
	Kurtosis	3.479938	3.444017	4.124421	4.195085
	Jarque-Bera	218.8551	207.0953	57.82572	60.17572
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	1007	1007	1006	1006
Copper	Mean	5.636561	5.636761	0.085553	0.081837
	Median	5.727499	5.722522	0.098644	0.000000
	Std. Dev.	0.251526	0.243017	1.742120	2.031561
	Skewness	-1.11467	-1.02361	0.034647	-0.17454
	Kurtosis	3.160728	2.955450	6.031930	5.916590
	Jarque-Bera	198.1659	166.3256	364.4471	341.8985
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	952	952	951	951

This fall in return is due to declining in the price of crude oil from Rs 6,299 on 15th July 2008 to Rs 1,695 on 13th February 2009. This variation in return is explained by the standard deviation. The volatility (standard deviation) of gold and copper log price returns reduces after the crisis whereas crude oil returns show an increase in volatility in the post-crisis period. However, chana's volatility remains almost the same across the two sub-periods. Out of the four commodities, crude oil returns are the most volatile.

Table 4.2: Descriptive Statistics in Post-Crisis Period

Commodity	Descriptive	LNFP	LNSP	RFP	RSP
Chana	Mean	8.049897	8.055713	0.065797	0.063466
	Median	8.025189	8.033837	0.046051	0.000000
	Std. Dev.	0.291107	0.299861	1.602219	1.413759
	Skewness	0.611724	0.589920	0.222650	0.605609
	Kurtosis	2.922599	2.781191	11.91549	8.350477
	Jarque-Bera	133.8759	128.2710	7095.214	2679.678
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	2138	2138	2137	2137
Gold	Mean	10.06933	10.06915	0.037990	0.038144
	Median	10.19647	10.19466	0.051760	0.000000
	Std. Dev.	0.271594	0.272440	1.056400	0.943768
	Skewness	-0.90425	-0.90017	-0.16359	0.383900
	Kurtosis	2.479420	2.466648	10.71404	13.29500
	Jarque-Bera	347.3758	345.8093	5844.603	10448.94
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	2354	2354	2353	2353
Crude Oil	Mean	8.289849	8.287077	-0.01241	-0.01204
	Median	8.253488	8.251925	0.030803	0.000000
	Std. Dev.	0.296718	0.297961	2.115572	2.333941
	Skewness	-0.25356	-0.2661	0.789883	0.393678
	Kurtosis	2.482673	2.508095	12.78154	8.662504
	Jarque-Bera	53.28898	53.32988	9964.689	3317.413
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	2437	2437	2436	2436
Copper	Mean	5.883072	5.876482	0.007479	0.007106
	Median	5.965121	5.959845	0.021504	0.000000
	Std. Dev.	0.235365	0.237239	1.487870	1.735860
	Skewness	-1.71992	-1.75865	-0.16301	-0.02445
	Kurtosis	6.036117	6.223540	8.376457	8.878916
	Jarque-Bera	2112.945	2284.798	2910.928	3467.926
	Probability	0.000000	0.000000	0.000000	0.000000
	Observations	2409	2409	2408	2408

Most of the log series are platykurtic in nature. As expected, the returns for all the return series in the pre-crisis and the post-crisis periods are leptokurtic. The nature of skewness also changes sign for all the sample commodities. Jarque bera statistic also suggests a non-normal distribution of returns. Therefore, it can be inferred that returns are not normally distributed.

4.2.1.2. Unit Root Tests Results

Here, graphical analysis of logarithmic series of spot and futures price movements of chana, gold, crude oil, and copper has been done (see Figures 4.2 to 4.5). The study reveals that all these graphs are upward trending. Thus, these series seem to be non-stationary.

Figure 4.2 (a): Log Price Movement of Chana (Chick Pea) in Pre –crisis Period

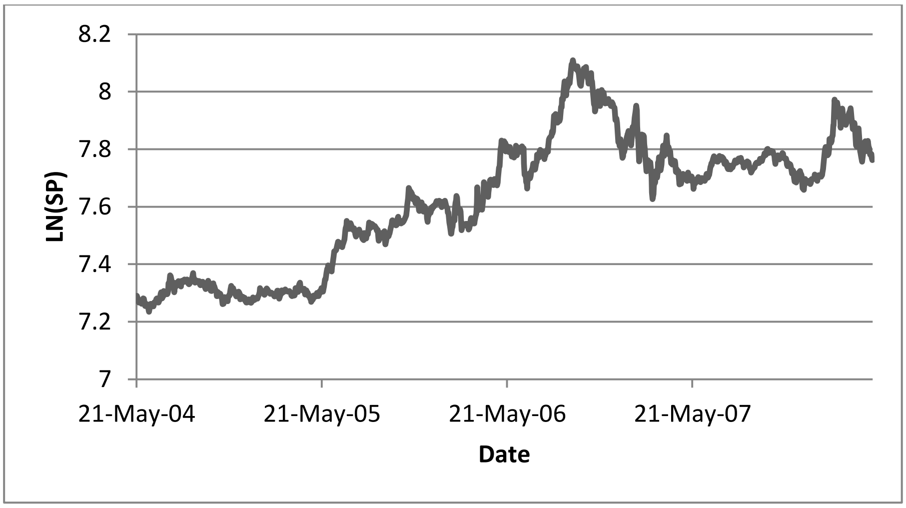
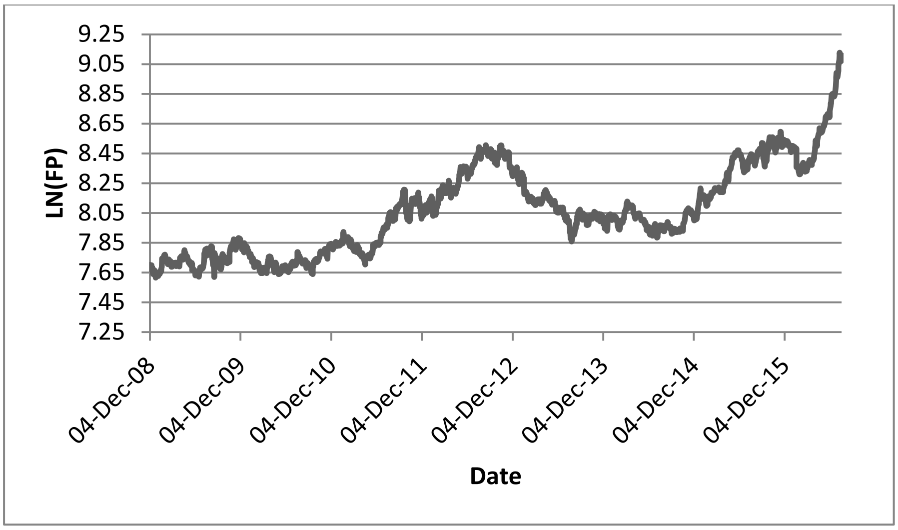


Figure 4.2 (b): Log Price Movement of Chana in the Post –crisis Period



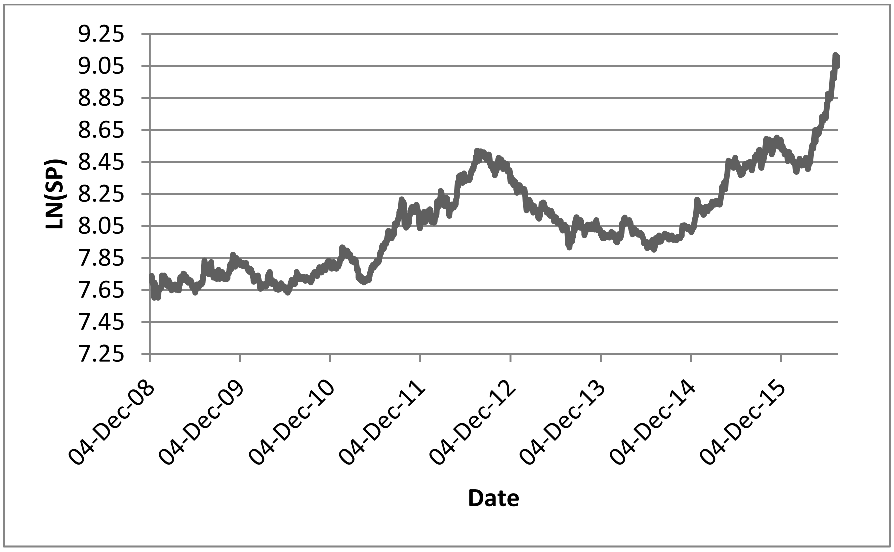
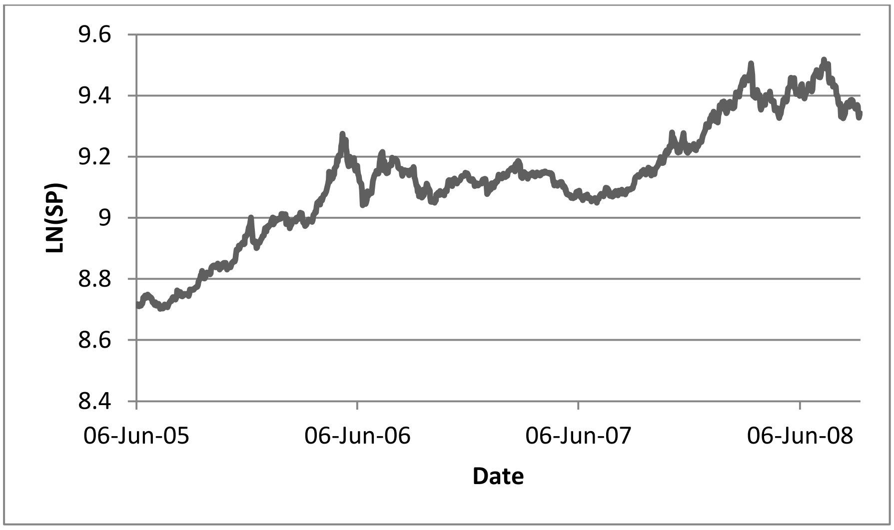


Figure 4.3 (a): Log Price Movement of Gold in the Pre-Crisis Period



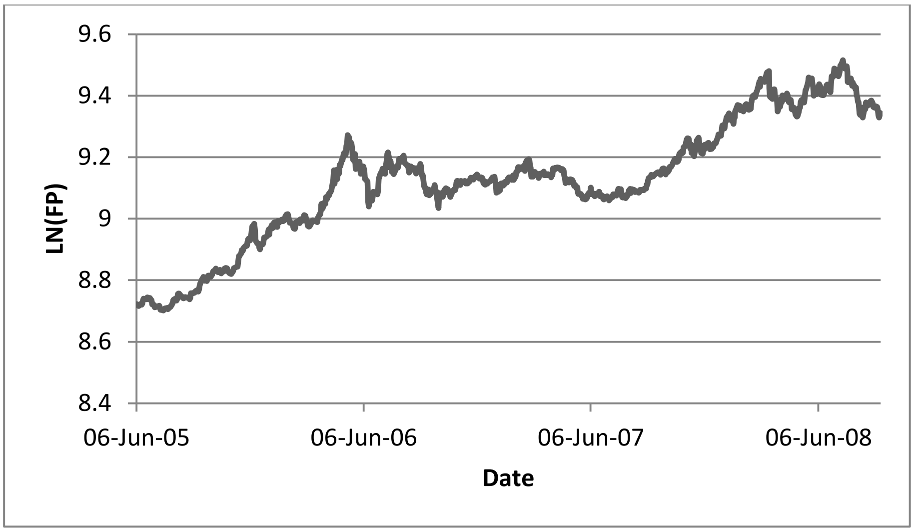
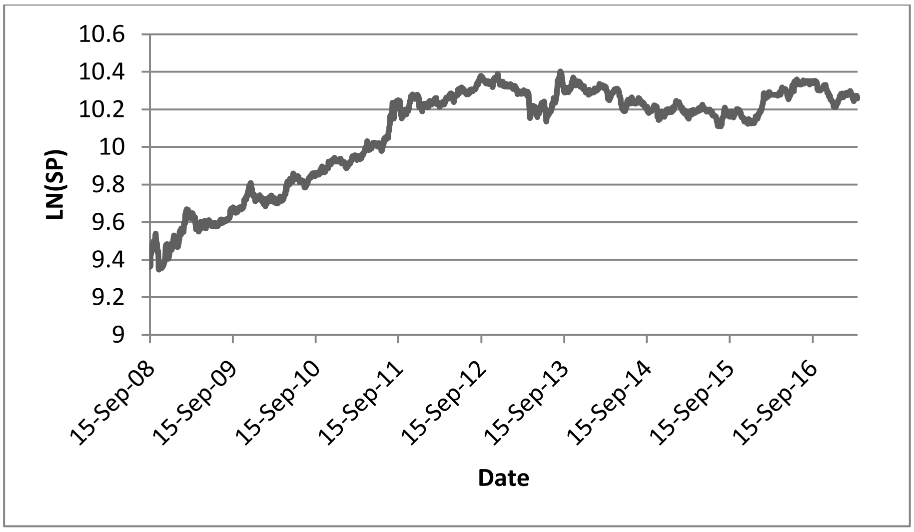


Figure 4.3 (b): Log Price Movement of Gold in the Post-Crisis Period



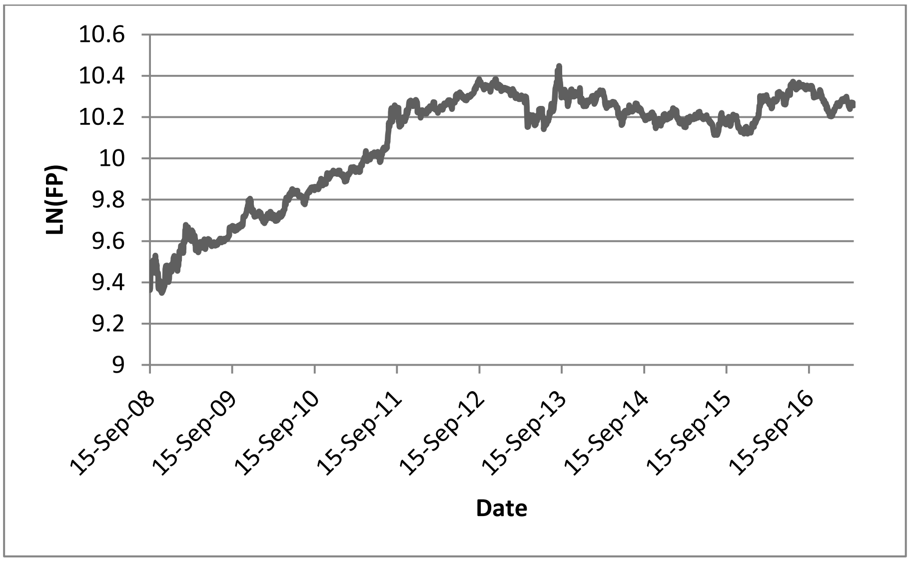
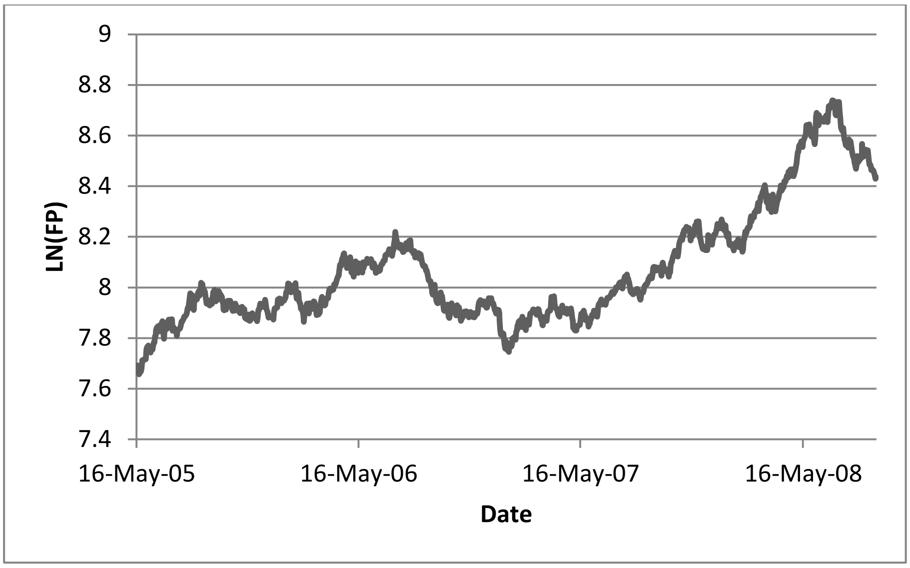


Figure 4.4 (a): Log Price Movement of Crude Oil in the Pre-crisis Period



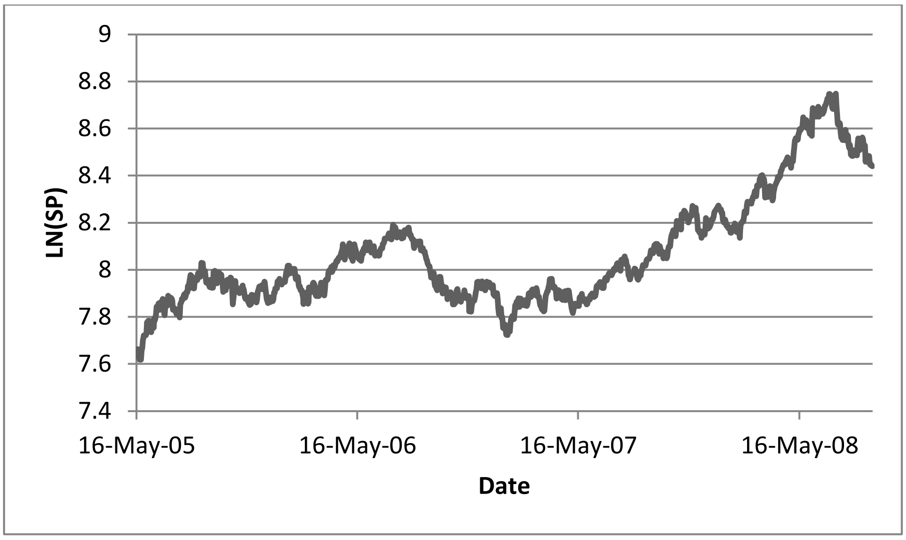
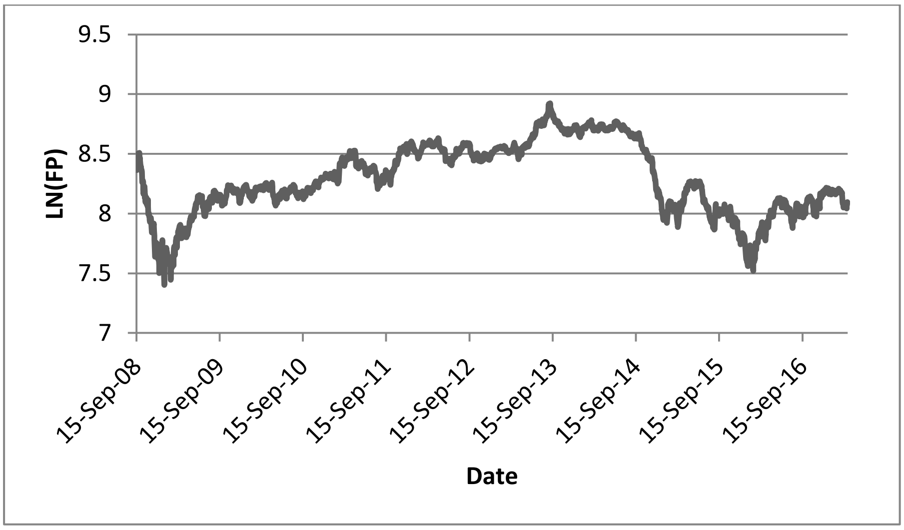


Figure 4.4 (b): Log Price Movement of Crude Oil Post-Crisis Period



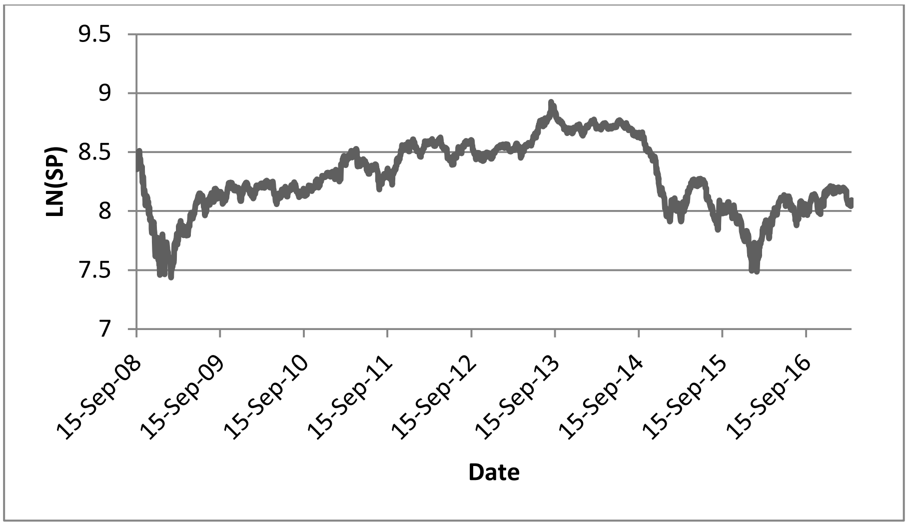
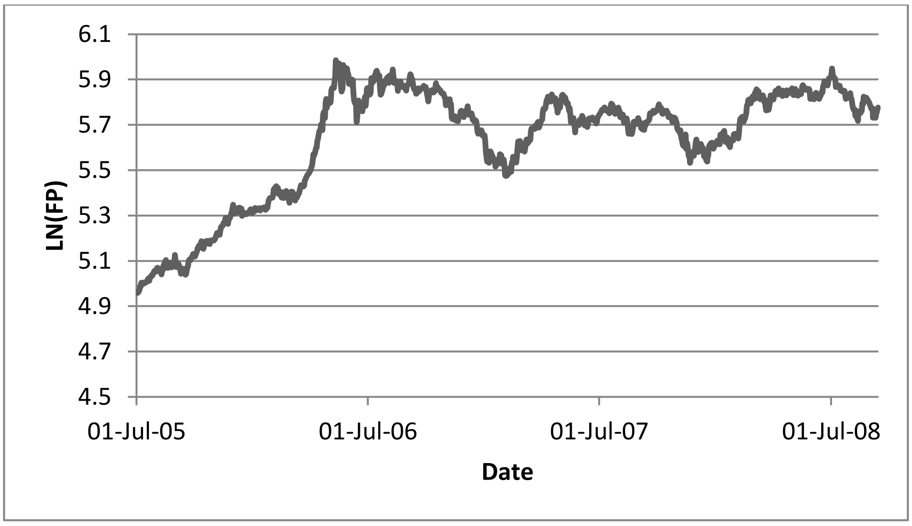


Figure 4.5 (a): Log Price Movement of Copper Pre-Crisis Period



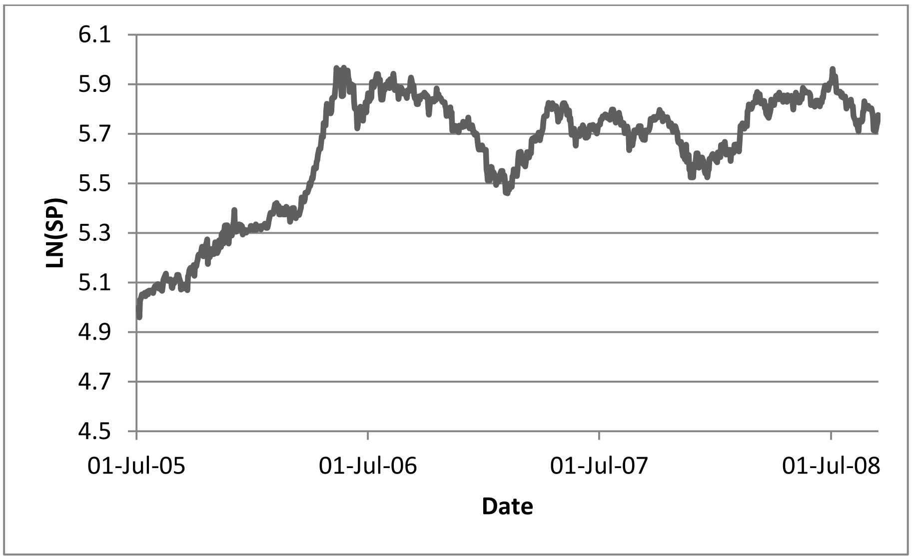
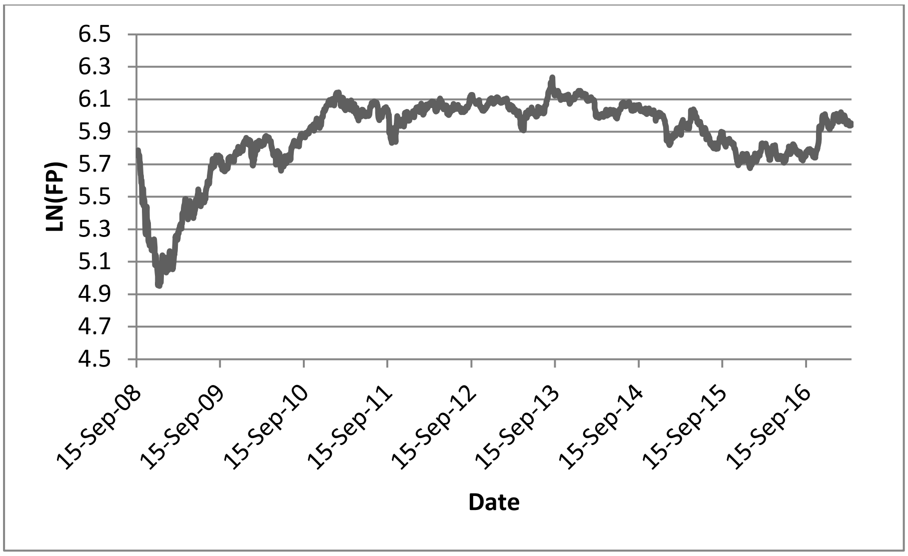
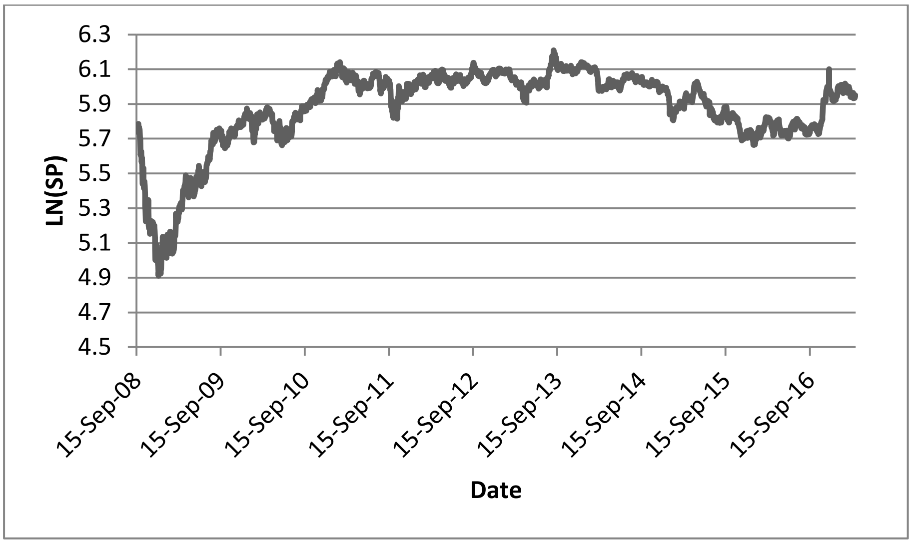


Figure 4.5 (b): Log Price Movement of Copper Post –Crisis Period





To confirm the finding of the graphical method, ADF and PP tests are employed. These tests have been employed on the log and return series of spot and future prices. The results have been shown in Table 4.3. It is apparent from the results that the null hypothesis of unit root cannot be rejected for spot and futures log prices series while it rejected for their return series at 5% level of significance. Thus, it is concluded that the log price series of all the sample commodities are first difference stationary, i.e., I(1). Both tests yield the same results. Thus, the results are robust.

Table 4.3: ADF and PP Tests Results

Commodity	Series	ADF		PP	
		Test Statistics	*p*-value	Test Statistics	*p*-value
		Pre-Crisis			
Chana	LNSP	-1.86	0.67	-1.72	0.74
	LNFP	-2.18	0.49	-2.16	0.51
	RSP	-31.27	0.00	-31.12	0.00
	RFP	-34.88	0.00	-34.89	0.00
Gold	LNSP	-2.04	0.58	-2.10	0.55
	LNFP	-1.93	0.64	-2.02	0.59
	RSP	-30.71	0.00	-30.71	0.00
	RFP	-31.27	0.00	-31.28	0.00
Crude Oil	LNSP	-1.83	0.69	-1.76	0.72
	LNFP	-1.61	0.79	-1.60	0.79
	RSP	-32.93	0.00	-32.95	0.00
	RFP	-31.56	0.00	-31.57	0.00
Copper	LNSP	-2.09	0.55	-2.09	0.55
	LNFP	-2.05	0.57	-2.03	0.58
	RSP	-34.78	0.00	-34.85	0.00
	RFP	-32.71	0.00	-32.68	0.00
		Post-Crisis			
Chana	LNSP	-0.26	0.99	-0.25	0.99
	LNFP	-0.38	0.99	-0.59	0.98
	RSP	-33.42	0.00	-42.10	0.00
	RFP	-43.98	0.00	-44.00	0.00
Gold	LNSP	-2.20	0.48	-1.97	0.62
	LNFP	-2.06	0.57	-2.03	0.58
	RSP	-49.05	0.00	-49.07	0.00
	RFP	-51.21	0.00	-51.17	0.00
Crude Oil	LNSP	-1.68	0.76	-1.73	0.74
	LNFP	-1.71	0.75	-1.70	0.75
	RSP	-54.47	0.00	-54.51	0.00
	RFP	-49.58	0.00	-49.58	0.00
Copper	LNSP	-1.79	0.71	-1.81	0.70
	LNFP	-1.68	0.76	-1.74	0.74
	RSP	-53.82	0.00	-53.86	0.00
	RFP	-48.66	0.00	-48.67	0.00

Critical value at 5% level of significance is -3.44.

4.2.2. Testing for Cointegration- Johansen's Cointegration

Before applying Johansen's cointegration test, the graphs of spot and futures prices are plotted for the sample commodities as shown in Figure 4.6. It is depicted that the spot and futures prices move in the same direction. Thus, they may be cointegrated.

Figure 4.6 (a): Price Movement of Chana

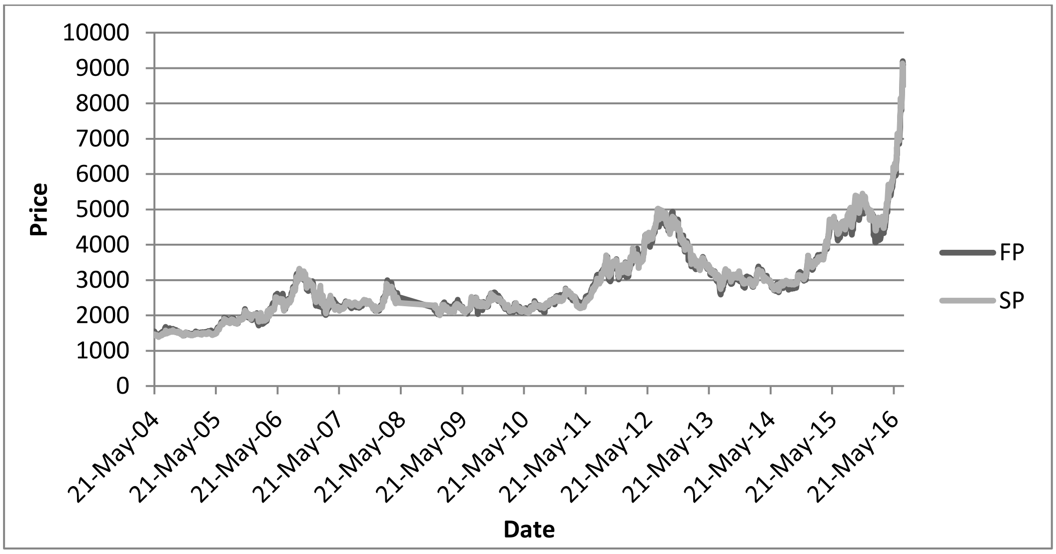


Figure 4.6 (b): Price Movement of Gold

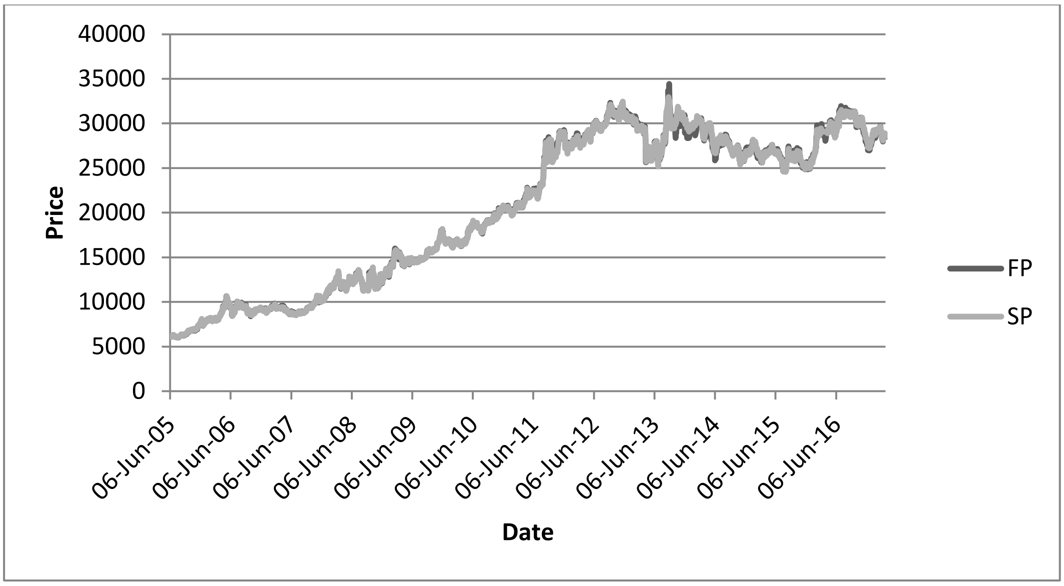


Table 4.4 depicts the results of Johansen cointegration test applied on the log series of SP_t and FP_t of sample commodities for both the sub-periods. The results for λ_{trace} and λ_{max} statistics suggest that there is one cointegrating relation for all sample commodities. For instance, for chana the null hypothesis of r = 0 is rejected at 5% significance level as the λ_{trace}

and λ_{max} statistics considerably exceeds the critical value of 15.49 and 14.26 respectively in both the pre and the post-crisis periods.

However, in the second row, the λ_{trace} and λ_{max} statistics is considerably less than the critical value of 3.84. So the null hypothesis of *at most one* cointegrating relation cannot be rejected in both the pre and the post-crisis periods. Similar results are obtained for gold, copper and crude oil.

Figure 4.6 (c): Price Movement of Crude Oil

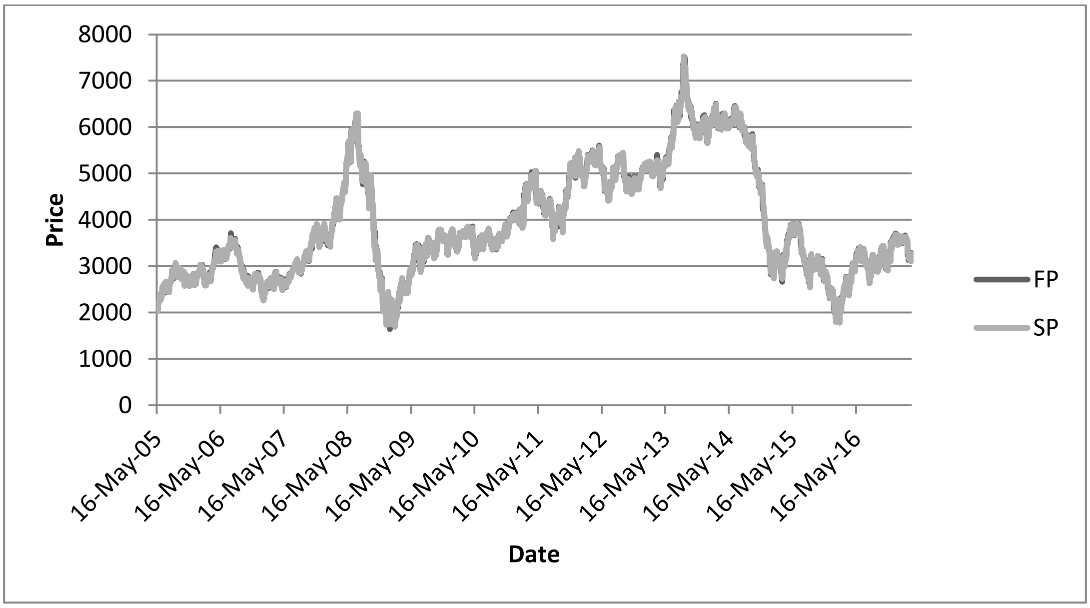
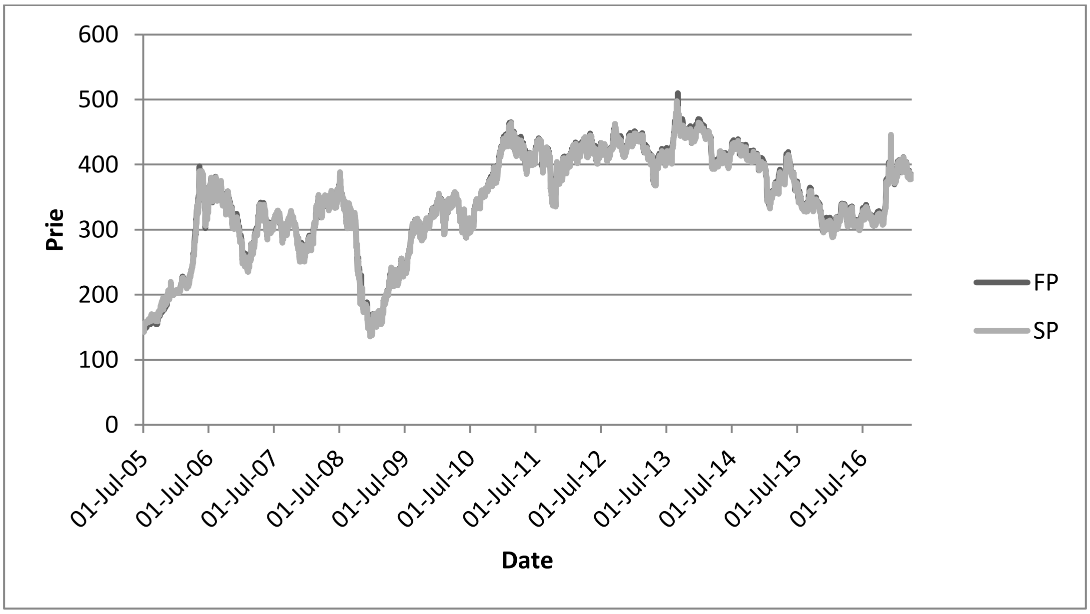


Figure 4.6 (d): Price Movement of Copper



Thus, from Johansen's test results it is inferred that the spot and futures prices are cointegrated for all the sample commodities. In other words, a long-run equilibrium relationship exists between spot and futures prices of the select commodities in both the sub-periods.

Table 4.4: Johansen Test; Number of Cointegrating relations for different cases

Commo-dity	r	Pre-Crisis			Post-Crisis		
		λ_{trace} Stats. (*p*-value)	λ_{max} Stats. (*p*-value)	Lags	λ_{trace} Stats. (*p*-value)	λ_{max} Stats. (*p*-value)	Lags
Chana	r=0	33.5110 (0.0000)	31.2294 (0.0000)	6	69.3693 (0.0000)	67.8298 (0.0000)	5
	r≤1	2.2811 (0.1310)	2.2811 (0.1310)	6	1.53963 (0.2147)	1.5396 (0.2147)	5
Gold	r=0	43.58418 (0.0000)	40.3133 (0.0000)	6	76.99725 (0.0000)	70.0695 (0.0000)	6
	r≤1	3.2708 (0.0705)	3.2708 (0.0705)	6	6.927804 (0.1303)	6.927804 (0.1303)	6
Crude Oil	r=0	87.0569 (0.0000)	85.6404 (0.0000)	4	243.3659 (0.0001)	240.5599 (0.0001)	9
	r≤1	1.416457 (0.2340)	1.416457 (0.2340)	4	2.805990 (0.0939)	2.805990 (0.0939)	9
Copper	r=0	26.18574 (0.0068)	18.20711 (0.0213)	8	138.2951 (0.0001)	135.2909 (0.0001)	6
	r≤1	7.978627 (0.0836)	7.978627 (0.0836)	8	3.004197 (0.0830)	3.004197 (0.0830)	6

Note: *r* represents hypothesised number of cointegrating equations. The p-values have been shown in parentheses. The critical values of λ_{trace} statistics are 15.4947 (r=0) & 3.84147 (r≤1), and λ_{max} statistics 14.26460 (r=0) & 3.84147(r≤1).

4.2.3. Analysing Causality- VEC Granger Causality

Since spot and futures prices are cointegrated, VEC Granger causality is applied to investigate the lead-lag relationship between the two series. The results of the causality test for the pre-crisis and the post-crisis periods have been shown in Table 4.5. A set of null hypothesis is reported for each commodity. The null hypothesis of ‘no Granger causality’ is rejected if the p-value is less than 0.05 or 5% level of significance. It is evident from the results that short-run causality association between spot and futures varies across the sub-periods for all the commodities except chana (chickpea).

For instance, in the case of crude oil, there is one –way causality directed from futures market to spot market in the pre-crisis period. It means crude oil futures market efficiently performs price discovery function in the pre-crisis period. However, in the post-crisis period, a bidirectional causality is observed between spot and futures prices of crude oil. It means causality runs from futures to spot market as well as from spot to futures market as feedback. It indicates that crude oil futures market in the pre-crisis period has a stronger ability to predict subsequent spot prices as compared to that in the post-crisis period. Thus, it is inferred that the crude oil futures market performs price discovery function more efficiently in the pre-crisis than the post-crisis period.

However, the results for gold and copper have been just opposite to that of crude oil. Both the commodities show a two-way causality between spot and futures markets in the pre-crisis period and one-way causality from futures to spot market in the post-crisis period. It signifies that the price discovery role of gold and copper futures market in has improved over time efficiently. On the hand, chana (chickpea) exhibits a consistent two-way short-run causality relationship between spot and futures prices in both the pre-crisis and the post-crisis periods. Thus, it is concluded that futures markets have ability to estimate spot prices for gold and copper is higher as compared crude oil and chana, and has improved across the periods.

Table 4.5: VEC Granger Causality/Block Exogeneity Wald Test Results

Commodity	**Null Hypothesis**	**Pre-crisis**		**During Crisis**	
		χ^2– value	**Prob.**	**χ^2- value**	**Prob.**
Chana	RFP ➡X➡ RSP	161.5885	0.000*	512.4981	0.000*
	RSP ➡X➡ RFP	22.07836	0.000*	11.29350	0.046*
Gold	RFP ➡X➡ RSP	1149.160	0.000*	657.0534	0.000*
	RSP ➡X➡ RFP	14.06981	0.029*	12.54002	0.051
Crude Oil	RFP ➡X➡ RSP	125.6287	0.000*	95.66469	0.000*
	RSP ➡X➡ RFP	4.138076	0.3876	35.74346	0.000*
Copper	RFP ➡X➡ RSP	1045.857	0.000*	1064.391	0.000*
	RSP ➡X➡ RFP	16.41140	0.012*	14.56156	0.203

* represents significant results at 5% level of significance.

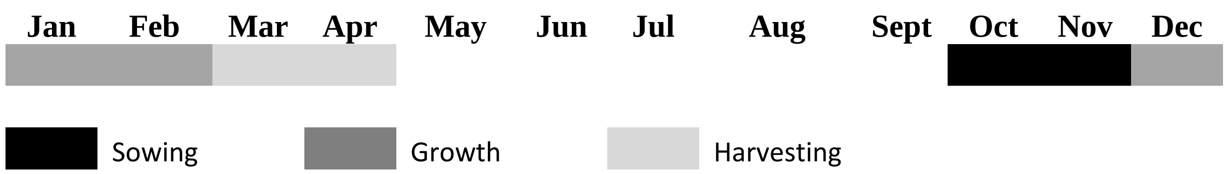
➡X➡ stands for "does not Granger cause"

From the results of cointegration and causality, it is concluded that the futures market for all select commodities namely chana, gold, crude oil, and copper are efficient. In efficient markets, any initiative taken on futures market will have an impact on its spot market (Raju and Karande, 2003 and Ali and Gupta, 2011).

4.3. Testing Seasonality

Chickpea or chana, an important pulse crop (legume) contributes about 71% to Rabi pulse production and 46% of the total pulse production in India. It is used for making flour (besan) which is popular in making sweets and snacks. Therefore, there is a major demand for chana during the festive season. Being an agri commodity, there is supply constraint during its cultivation season which is expected to affect its price in the spot market. Figure 2 shows the crop cultivation pattern of chana in India. Chana sowing starts during October and is harvested during the March-April period. During sowing period traders start hoarding chana in expectation of rise in price. However, due to earlier sowing in south India, chana arrivals begin in February in South India and March onwards in North India. The seasonality in production may influence the nexus between spot and futures market of chana and affect the efficiency of the futures market.

Figure 4.7: Chana Cultivation Pattern in India



The results of regression model are shown in Table 4.6 for chana. In table 4.6, the result is significant for the coefficient β in the regression model, i.e., the null hypothesis of β =0 is rejected. Since the F-significance value is zero that is less than the level of significance (0.05), it means that the explained variation of the model is significantly different from the error term. Thus, there is a long run equilibrium relationship between the spot and futures prices, and chana futures prices effect spot prices of chana.

Table 4.6: Regression Results

Regression Model	β	p	Adj. R^2	D W Stat	Sign. F
$RSP_t = \alpha + \beta RFP_t + \epsilon_t$	0.44430	0.000	0.25319	2.4154	0.000

Before introducing a dummy to analyse the effect of seasonality, it is important to test whether the relationship between an explained and the explanatory variables is linear or not. This study employs Ramsay RESET test for the given regression model. The results have been reported in Table 4.7. From the results shown in Table 4.7, the p-value for *FITTED^2 = 0.1850* is greater than the level of significance 0.05. Thus, the null hypothesis of a linear association between the spot and futures price returns cannot be rejected at 5% level of significance. So, it is concluded that the association between natural logarithmic returns on spot price and natural logarithmic returns on futures prices is linear in nature.

Table 4.7: Results of Ramsay RESET test

	Regression Model Eq. 1		
	Value	**DF**	**Prob.**
t-statistic	1.325963	2134	0.1850
F-statistic	1.758178	(1, 2134)	0.1850
Likelihood ratio	1.759925	1	0.1846
Variable	**Coefficient**	**Std. Error**	**Prob.**
C	0.044771	0.027615	0.1051
Return on ln(FP)	0.446961	0.016618	0.0000
FITTED^2	-0.020985	0.015826	0.1850

To analyse the effect of seasonality, dummy is added to the regression model (Gay and Kim, 1987). Table 4.8 shows the results of seasonality test. The results show that there is significant effect of futures returns on spot prices returns while the effect of seasonality is insignificant. It means the relationship between the chana spot and futures prices is not affected by the seasonality.

Table 4.8: Seasonality Test Results

Regression Model	***Futures Return***		**Dummy**		**Adj. R^2**	**Sign. F**
	β_1	*p*	β_2	*p*		
$RSP_t = \alpha + \beta_1 RFP_t + \beta_2 Dummy + \epsilon_t$	0.443	0.00	0.045	0.394	0.253	0.000

The results of Johansen's Cointegration test suggest that spot and futures market bear a long-run equilibrium relationship for all the select commodities. The results of VEC Granger causality show a short run causal association between spot and futures market for all the select commodities. This leads to the conclusion that futures markets of chana (chickpea), gold, crude oil, and copper are efficient in performing price discovery role in the two sub-periods. The analysis of the seasonality effect in case of chana shows that there is no impact of seasonality crop pattern on the association between spot and futures markets.

CHAPTER 5

COMMODITY FUTURES & INFLATION IMPACT ANALYSIS

5.1. Introduction

Inflation is a matter of economic concern all over the globe. The Government of India (GoI) confronted the problem of rising wholesale price index (WPI) inflation from mid-2006 to the beginning of 2007. WPI breached a level of 6.69% while CPI touched 9.8% mark. There was disagreement among academicians and researchers, regulatory bodies and political parties on the reason behind the rising prices. In early 2007, India's parliamentary standing committee on food and public distribution held futures trading responsible for inflation in India and suggested to ban futures trading in essential agricultural commodities. Following the suggestions of the panel and increasing pressure from political circles, the GoI banned futures trading on some essential agro-commodities like wheat, rice and two varieties of lentils while temporarily suspended futures trading in commodities like chana (chick pea), soyoil, rubber, and potato. The ban triggered investigations on the relationship between agricultural commodity futures and inflation. This study aims to bridge up the research gap by analyzing the causal relationship between commodity (argi, metals, and energy) futures trading, and commodity specific Wholesale Price Index (WPI) inflation in India.

Most of the available literature on the inflationary effect of futures trading viz. Kamara (1982), Singh (2000), Yang et al. (2005), Ranjan (2005), Karande (2007), IIMB (2008), Sen (2008) and Gupta and Varma (2016) examine the volatility of spot market pre and post introduction of futures. While the other set of available literature on inflationary effect of futures trading uses Granger causality and other tests (Nath and Lingareddy, 2008; Sahoo and Kumar, 2009; Sehgal et al. 2012; Gupta and Ravi 2013; Ahmad and Sehgal 2015; Lakshmi et al. 2015; Gupta and Varma, 2016 and Sharma, 2016). The literature presents conflicting findings varying from stabilizing effect (Ranjan, 2005; Karande, 2007; Sen, 2008; Sahoo and Kumar, 2009; Bose, 2007; Nair and Eapen, 2012; Deloitte, 2013; Bohl and Stephan, 2013; Rajib, 2015; Jégourel and Verdié, 2015 etc.) to destabilizing effect (Yang et al., 2005; Sahi and Raizada, 2006; Gorton and Rouwenhorst, 2006; Sahi, 2007; Sehgal et al., 2012 and Sharma, 2016) to mixed effect (Gupta and Ravi, 2013; Ahmad and Sehgal, 2015; Lakshmi et al., 2015; Zavaleta-Vázquez and Arenas, 2016 and Gupta and Varma, 2016) of futures trading on spot market volatility and inflation. This study uses Toda Yamamoto (TY) modified Granger causality approach to analyse the inflationary effect of commodity futures trading in India.

5.2. Data & Analysis

Table 5.1 shows some vital details on monthly futures volume data. The present study uses monthly data on futures trading volume and commodity specific WPI. The study does not use any specific contract *(near/mid/far month)* for futures trading volume. For analysing inflationary impact of futures trading, the monthly trading volume of each selected commodity has been taken into account. The data on monthly trading volume of gold, crude oil and copper have been taken from MCX while that of chana has been taken from NCDEX. First, the data is diagnosed for missing values and outliers. Chana futures volume data is found to have some missing values. The average of preceding and succeeding values is used in place of missing values. The futures trading on chana was banned in June 2016. The ban was lifted in July 2017, and the trading was reassumed. So, this study considers chana futures data until May 2016.

Table 5.1: Selected Commodities Data Details

Commo-dity	Futures Market	Period		Number of observations	
		From	To	Before removing Outliers	After removing Outliers
Chana (chickpea)	NCDEX	January 2005	May 2016	135	133
Gold	MCX	May 2005	March 2017	72	71
Copper	MCX	February 2006	February 2017	56	56
Crude Oil	MCX	July 2005	March 2017	140	139

Volume series of all select commodities except copper are found to have outliers. The outlier observations have been removed for both futures volume and WPI series before proceeding for analysis (see Table 5.1). TY modified Granger causality test requires to know the true lag length and maximum order of integration of the sample series. The following sub-sections deal with this requirement.

5.2.1. Unit Root Test and VAR Optimal Lag Length

Here, Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests have been used to calculate the maximum order of integration (d_{max}). If a series is I(0) and another series is I(1), then d_{max} is equal to 1. The results of ADF and PP tests for futures trading volume and commodity specific WPI inflation series of all four commodities are shown in Table 5.2. It is evident from the results that trading volume series is stationary in levels in case of chana, gold, and copper while it is first difference stationary in case of crude oil. Similarly, the WPI series of chana, gold and crude oil are stationary on first differencing while that of copper is stationary in level. Thus, the maximum order of integration k (i.e., maximum of the order of integration of trading volume and WPI inflation series) is 1 for crude oil, gold, and chana while it is zero for copper.

Table 5.2: Determining k and d_{max}

Comm--odity	Series	Stationarity at Level/ 1st Difference	Test Form	Test Stat. (*p*-value)		VAR Optimal Lag order k#	Maximum integration order (*d*max)
				ADF	PP		
Crude Oil	Volume	First Difference	Intercept	-11.13 (0.00)	-11.12 (0.00)	1,2	1
			Trend & Intercept	-11.11 (0.00)	-11.10 (0.00)		
	WPI	First Difference	Intercept	-12.60 (0.00)	-12.62 (0.00)		
			Trend & Intercept	-12.68 (0.00)	-12.75 (0.00)		
Gold	Volume	Level	Intercept	-3.42 (0.01)	-3.50 (0.01)	1,1	1
			Trend & Intercept	-4.43 (0.00)	-4.44 (0.00)		
	WPI	First Difference	Intercept	-7.66 (0.00)	-7.66 (0.00)		
			Trend & Intercept	-8.17 (0.00)	-8.16 (0.00)		
Copper	Volume	Level	Intercept	-5.36 (0.00)	-5.15 (0.00)	1,1	0
			Trend & Intercept	-5.09 (0.00)	-5.09 (0.00)		
	WPI	Level	Intercept	-12.42 (0.00)	-12.20 (0.00)		
			Trend & Intercept	-10.89 (0.00)	-10.88 (0.00)		
Chana (chickpea)	Volume	Level	Intercept	-3.91 (0.00)	-3.87 (0.00)	2,2	1
			Trend & Intercept	-3.81 (0.02)	-3.74 (0.02)		
	WPI	First Difference	Intercept	-6.14 (0.00)	-6.19 (0.00)		
			Trend & Intercept	-6.12 (0.00)	-6.16 (0.00)		

Note : #Given in the order by SIC & AIC. Critical values for ADF test are -2.89 & -3.45 and that of PP test are -2.883073 & -3.44370 at 5% level of significance.

After knowing the maximum order of integration, it is required to find the optimal lag order of VAR. Here, AIC and SBIC criterions have been used to determine optimal lag length k. In all cases except crude oil, a consensus has been found in AIC and SBIC criterions for optimal lag lengths. In other words, there is variation in the value of k across these criterions as well as the commodities. From Table 5.2, k = 1 for gold and copper, k = 2 for chana while k = 1 or 2 for crude oil.

5.2.2. Toda Yamamoto Modified Granger Causality Results

It has been observed that Granger causality results vary with change in lag length (Wolde-Rufael, 2004). Therefore, this study conducts TY modified Granger causality test for different values of $k+d_{max}$. For instance, the value of k varies from 1 to 2 with d_{max} equals to 1 for crude oil (see Table 5.3). So, the causality test for $k+ d_{max} = 2$ and $k+ d_{max} = 3$ has been employed where only k (1 or 2) forms lags for endogenous variables while $(k+ d_{max})$th lag of each variable forms exogenous variable. Thus, the coefficients of these 2nd or 3rd extra lags will not be included when the Granger Causality/Block Exogeneity Wald Test is performed. Therefore, the degree of freedom takes a value of '1 or 2' and not '2 or 3'.

Table 5.3: TY Version of Granger Causality Test

Commodity	Null Hypothesis	Chi-square (p-value) for different VAR Lengths $k+d_{max}$		
		1	2	3
Crude Oil	*lnwpi* ➡✕➡ *lnfv*	NA	0.47 (0.49)	1.64 (0.43)
	lnfv ➡✕➡ *lnwpi*	NA	6.98(0.01)	7.71 (0.02)
Gold	*lnwpi* ➡✕➡ *lnfv*	NA	0.04 (0.83)	NA
	lnfv ➡✕➡ *lnwpi*	NA	0.36 (0.54)	NA
Copper	*lnwpi* ➡✕➡ *lnfv*	4.44 (0.04)	NA	NA
	lnfv ➡✕➡ *lnwpi*	1.04 (0.31)	NA	NA
Chana	*lnwpi* ➡✕➡ *lnfv*	NA	NA	0.98 (0.61)
	lnfv ➡✕➡ *lnwpi*	NA	NA	3.97 (0.14)

➡✕➡ means "does not Granger cause"

Table 5.3 shows results of TY modified Granger causality test for $k+ d_{max}$ lag lengths of 1 to 3 for different commodities. This has been done to analyze the robustness of results. The null hypothesis of no causality from log series of commodity specific WPI (wholesale price index) *lnwpi* to logarithmic series of trading volume of that commodity *lnfv* cannot be rejected for gold, crude oil, and chana at 5% level of significance. Similarly, for copper, the null hypothesis of no casualty from *lnwpi* to *lnfv* cannot be rejected at 1% level of significance. It means there is *lnwpi* does not Granger cause *lnfv*, in any case, i.e., gold, copper, crude oil, and chana. On the other, the null hypothesis of no causality from futures trading volume to WPI is rejected for crude oil only out of the four sample commodities. It means ‘trading volume of crude oil' Granger causes ‘crude oil WPI.' The results are robust as the findings don't change even with a change in lag length. Thus, it can be said that crude oil futures trading results in a surge in prices of crude oil in the spot market. Similar results have been reported by Sahoo and Kumar (2009) while Lakshmi (2015) reports contrasting results. On the other hand, it is inferred from results that there is no causality running from futures trading volume to WPI inflation for gold, copper, and chana (chickpea). These results are akin to the results of a study by Sahoo and Kumar (2009). For chana, a recent study by Ahmad and Sehgal (2015) reports contrasting results. In a nutshell, no relationship is found between futures trading and inflation for three out of four select commodities. Thus, it is concluded that this study does not have sufficient evidence to support that commodity futures trading has led to higher inflation in India. Out of a very few studies on the inflationary effect of commodity (both agri and non-agri) futures market, these results are alike the results reported by Bohl and Stephan (2013) and Sahoo and Kumar (2009).

Thus, the results of this study are relevant to the government and the market regulator for a suitable policy framework to further promote and develop the commodity futures market without any apprehension about its inflationary impact. Moreover, the results are useful in building up market participants' confidence in futures trading that would further help the market grow and increase its breadth and depth.

CHAPTER 6

INTERNATIONAL LINKAGE AND VOLATILITY ANALYSIS

6.1. Introduction

Over the last couple of decades, financial integration and volatility of international markets have increased (Mensi et al., 2013). International linkage of markets proved to be a bane for events like the recent global financial crisis (GFC) that affected stock and commodity markets almost all over the globe. It dried up liquidity and increased volatility in markets (Sharma and Misra, 2011). The collapse of Lehman Brothers during the global financial crisis resulted in the increase in price volatility of many commodities (Cheng and Xiong 2014). Futures prices play a better role than cash prices, in absorbing and reflecting market information for high trade volume commodities like crude oil in international markets (Yang et al. 2001). But there is a dearth of studies on the international linkage of the Indian commodity futures market and the effect of GFC on the volatility of the spot market of internationally traded commodities like crude oil, gold and copper. Given the nascent stage of the Indian commodity futures market, these issues become extremely imperative and hence need to be investigated.

6.2. Analyzing International Linkage of Indian Commodity Futures Market

This section deals with the analysis of international linkage of Indian futures market of gold, crude oil and copper with its world counterparts over the recent eight years in the post-crisis period .i.e. April 2009 to March 2017. This study employs Johansen's cointegration and Granger causality techniques to analyze the linkage and causality between the select markets. Before applying the Johansen cointegration technique, it is important to examine the two series for unit roots. This study employs ADF and PP tests on the natural log of futures prices. Table 6.1 shows the results for the first difference of futures price series of crude oil, gold, and copper traded in different markets. It is evident from the results that the null hypothesis of non-stationarity is rejected for all the series under ADF as well as PP tests. In other words, the select series are the first difference stationary or I(1).

Table 6.1: Results of ADF and PP Test (First Difference)

Comm- -odity	Series	Market	Test Form	Test Stat. (*p*-value)	
				ADF	**PP**
Crude Oil	LMCO	MCX	Intercept	-44.37 (0.00)	-44.37 (0.00)
			Trend & Intercept	-44.40 (0.00)	-44.40 (0.00)
	LNYCO	NYMEX	Intercept	-48.91 (0.00)	-48.91 (0.00)
			Trend & Intercept	-48.90 (0.00)	-48.90 (0.00)
Copper	LMC	MCX	Intercept	-43.27 (0.00)	-43.28 (0.00)
			Trend & Intercept	-43.31 (0.00)	-43.33 (0.00)
	LSHC	SHFE	Intercept	-39.16 (0.00)	-39.11 (0.00)
			Trend & Intercept	-39.21 (0.00)	-39.13 (0.00)
Gold	LMG	MCX	Intercept	-46.06 (0.00)	-46.09 (0.00)
			Trend & Intercept	-46.12 (0.00)	-46.14 (0.00)
	LNYG	NYMEX COMEX	Intercept	-44.68 (0.00)	-44.68 (0.00)
			Trend & Intercept	-44.73 (0.00)	-44.74 (0.00)

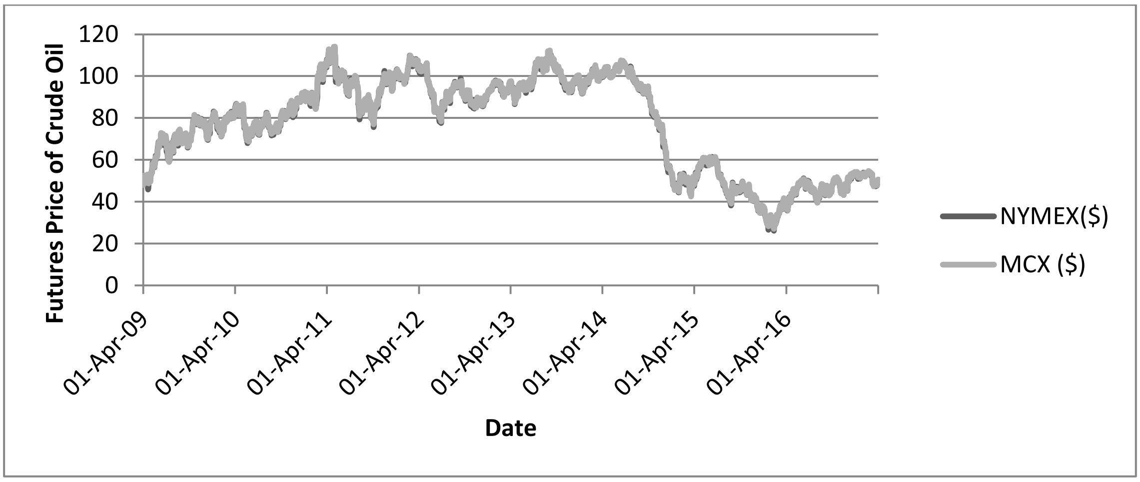
NOTE: Figures in parenthesis show represent p-values. Critical values for ADF test are -2.89 & -3.45 and that of PP test are -2.883073 & -3.44370 at 5% level of significance. *LMCO:* log of MCX crude oil futures price; *LNYC:* log of NYMEX crude oil futures price; *LMC:* log of MCX copper futures price; *LSHC:* log of NYMEX copper futures price; *LMG:* log of MCX gold futures price; *LNYG:* log of NYMEX gold futures price.

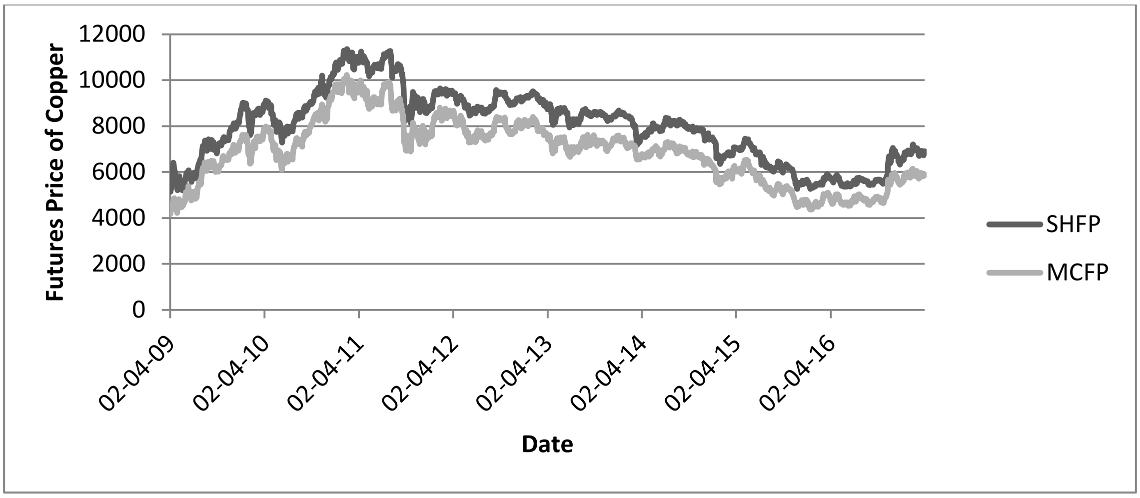
6.2.1. Johansen Cointegration Test

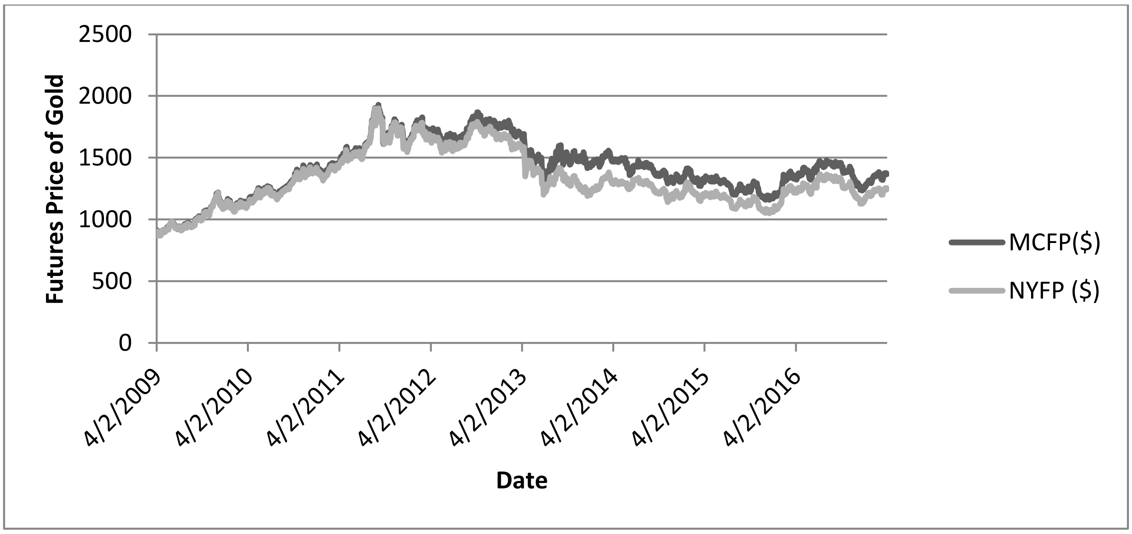
The futures prices of gold, crude oil, and copper at Multi Commodity Exchange (MCX) have been tested for cointegration with the futures prices at New York Mercantile Exchange (NYMEX)-COMEX, NYMEX, and Shanghai Futures Exchange (SHFE) respectively.

The graphs of futures prices of gold, crude oil and copper for different markets are shown in Figure 6.1. The graphs depict that the spot and futures prices move in the same direction. Thus, the futures prices at MCX may be cointegrated with futures prices at foreign market for gold, crude oil, and copper.

Figure 6.1.: Price Movements of Crude Oil, Copper and Gold Futures Prices







To confirm, Johansen's cointegration test is applied. The results of Johansen's test for $\lambda_{trace}$and λ_{max} for different commodities have been reported in Table 6.2. For trace test in case of crude oil and copper, the null hypothesis of no cointegrating vector is rejected, but that of *at most one* cointegrating vector is not rejected at 5% level of significance. The max test confirms the result of the trace test. The results suggest that in case of crude oil there is one cointegrating relation between futures market at MCX and NYMEX. Similarly, there is one cointegrating relation between futures market at MCX and SHFE for copper. However, there is no cointegration between futures market at MCX and NYMEX-COMEX for gold. Here, AIC criterion has been used for optimal lag length selection (see Table 6.2).

Table 6.2: Johansen Test; Number of Cointegrating relations for different cases

Commodity	**Series**	**r**	**λ_{trace} Stats. (*p*-value)**	**λ_{max} Stats. (*p*-value)**	**Lags**
Gold	*LMG & LNYG*	r=0	14.31122 (0.0748)	11.1900 (0.1449)	9
		r≤1	3.121212 (0.0773)	3.121212 (0.0773)	
Crude Oil	*LMCO & LNYCO*	r=0	487.8497 (0.0001)	486.0606 (0.0001)	2
		r≤1	1.789100 (0.1810)	3.841466 (0.1810)	
Copper	*LMC & LSHC*	r=0	75.40365 (0.0000)	71.85621 (0.0000)	6
		r≤1	3.547449 (0.0596)	3.547449 (0.0596)	

Note: r represents hypothesised number of cointegrating equations. The p-values have been shown in parentheses. The critical values of λ_{trace} statistics are 15.4947 (r=0) & 3.84147 (r≤1), and λ_{max} statistics 14.26460 (r=0) & 3.84147(r≤1). LMCO*:* log of MCX crude oil futures price; *LNYC:* log of NYMEX crude oil futures price; *LMC:* log of MCX copper futures price; *LSHC:* log of NYMEX copper futures price; *LMG:* log of MCX gold futures price; *LNYG:* log of NYMEX gold futures price.

Therefore, this study concludes that the crude oil and copper futures market at MCX, individually bear long-run equilibrium with their respective world counterpart markets while there is no cointegration between gold futures at MCX and gold futures at NYMEX-COMEX. Alike results are reported by Kumar and Pandey (2011).

6.2.2. Granger Causality Test Results

Depending upon the cointegrating relationship between the given series, Granger causality test has been employed in two different forms to examine short run causality. In case of gold where the series are not cointegrated, the Granger Causality test (Granger, 1969) is applied. However, in case of crude oil and copper where the given series are cointegrated, the VEC Granger Causality has been applied. The results of the causality test are shown in Table 4.5.

Table 6.3.: VEC & VAR Granger Causality Test Results

Commodity	Null Hypothesis	χ^2– value	Prob.
Crude Oil	RLNYCO ➡✖➡ RLMCO	0.649674	0.7226
	RLMCO ➡✖➡ RLNYCO	2.454527	0.2931
Copper	RLSHC ➡✖➡ RLMC	19.95915	0.0028*
	RLMC ➡✖➡ RLSHC	623.4235	0.012*
Gold#	RLMG ➡✖➡ RLNYG	1.23434	0.2746
	RLNYG ➡✖➡ RLMG	47.3052	0.000*

Reported results are for Pairwise Granger Causality Tests.

* represents significant results at 5% level of significance.

➡✖➡ means "does not Granger cause"

A set of null hypothesis is reported for each commodity. For crude oil, the null hypotheses of *no Granger causality* from log return of MCX crude oil futures prices (RLMCO) to log return of NYMEX crude oil futures price (RLNYCO), and from RLNYCO to RLMCO cannot be rejected as the *p*-value of χ^2 is greater than 5% (0.05) level of significance. Thus, the results reflect that there is no short-run causality relationship between crude futures prices returns at MCX and NYNEX. On the contrary, there is two-way causality between the log return of MCX copper futures prices (RLMC), and log return of SHFE copper futures price (RLSHC). However, in the case of gold, the results indicate that there is causality running from log return of NYMEX-comex gold futures price (RLNYG) to log return of MCX gold futures prices (RLMG).

While analyzing cointegration between futures markets of two countries, the Efficient Market Hypothesis said to be violated if the two markets are cointegrated (Rapp and Sharma, 1999; Baillie and Bollerslev, 1989 and Hakkio and Rush, 1989). In other words, the markets are said to be inefficient if they are cointegrated. Thus, from the above empirical analysis results, it is concluded that futures markets of copper and crude oil are not efficient as their market at MCX and their respective foreign futures market are cointegrated. However, the gold futures market at MCX and NYMEX are not cointegrated and hence efficient. However, the gold futures market at NYMEX-comex leads MCX market.

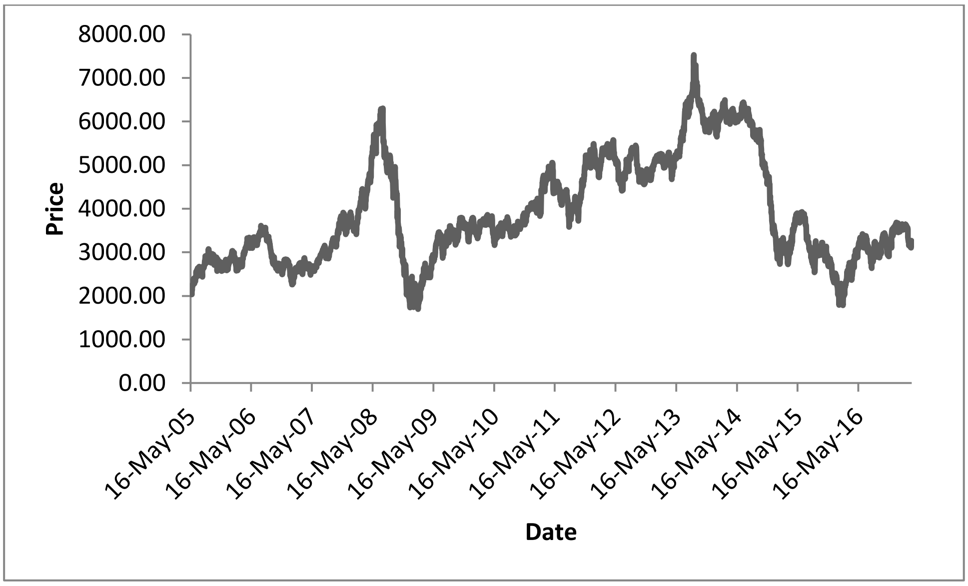
6.3. Analysis of Global Financial Crisis and Crude Oil Spot Market Volatility

Crude oil is one of the most crucial energy sources worldwide. It accounts for 35% of the world's primary energy consumption. For an emerging economy like India, about one-third of energy requirement is met through crude oil. More than 80 percent of crude oil demand is fulfilled through imports. India imported crude oil worth USD 169.25 billion in 2012-13, which was more than one-third of her total import bill (Kumar, 2014). India had imported crude oil for USD 70.196 billion and USD 88 billion in 2016-17 and 2017-18 respectively. This figure is likely to jump 24% to USD 109 billion in 2018-19. India relies on imports to meet its oil needs.

Crude oil prices keep on fluctuating in the international market due to one or the other factor. It may be due to increased tension between two major oil-producing countries Iran and Saudi Arabia, weak Asian trade and plunging economic growth of China - the largest consumer of crude oil, the sporadic fights involving Israel and her neighbours, American threats to denuclearize Iran, tensions in the Korean Peninsula, Arab Spring in the MENA region, Brexit announcement etc. A rise or fall in oil prices has a direct or indirect effect on the current account deficit, inflation, and Indian currency. Thus, fluctuations in oil prices, unless managed, have the potential to disrupt the smooth functioning of the nation's economy (Kumar, 2014).

Abrupt changes in market forces due to factors like the GFC 2008 and rapid economic growth of China influence expectations of future prices and hence result in current price changes (Huntington et al., 2012). As a result, crude oil prices continue to remain volatile even after in the post-financial crisis period (Kumar, 2014). Basics being the same, the stochastic properties of spot and futures prices may differ in during the period of turmoil (Bessembinder et al., 1995). Figure 6.2 displays the spot price movements of crude oil in Mumbai Market, India for around twelve years from May 2005 to March 2017. The graph depicts the largest free fall in oil prices during the global financial crisis of 2008 and second fall of 2014 due to sluggish global economic recovery, too much supply chasing too little demand and political tensions for some major exporting countries. Thus, the GFC 2008 could have influenced the ambiguity underlying oil demand affecting the volatility of the price of oil (Caporalae et al., 2010).

Figure 6.2: Price Movement in Crude Oil Prices



6.3.1. Descriptive Statistics

In Table 6.4, descriptive statistics of natural logarithmic return of spot price of crude oil has been shown for the pre-crisis period (May 16, 2005 to September 14, 2008), post-crisis period (September 15, 2008 to 31 March, 2017) and the whole period (May 16, 2005 to 31 March, 2017). For all the three periods, average returns are approximately zero. The average daily returns on crude oil have fallen drastically from +0.07 in the pre-crisis period to -0.01 in the post-crisis period. This fall in return is due to a decline in the price of crude oil from Rs 6,299 on 15th July 2008 to Rs 1,695 on 13th February 2009. This volatility or variation in return is explained by the standard deviation across the sub-periods. The volatility of crude oil returns shows an increase in volatility in the post-crisis period. However, the estimates of standard deviations are not so useful in case of high kurtosis (Verma and Mahajan, 2012).

In the pre-crisis period, the returns are a negatively skewed while for the whole period and the post-crisis, the average returns have become more positively skewed. Also, leptokurtic nature of distribution - a peculiar characteristic of financial time series, has increased to more than twice after the recent global turmoil. The zero probability values for Jarque Bera test imply that the crude oil returns for all the periods do not follow the normal distribution.

Table 6.4: Descriptive Statistics for Spot Price Daily Return Series of Crude Oil

	Whole	Pre	Post
Mean	0.012661	0.077951	-0.01204
Standard Deviation	2.198093	1.820306	2.333941
Kurtosis	8.361554	4.195085	8.662504
Skewness	0.312628	-0.04294	0.393678
Jarque Bera (Prob.)	4179.976 (0.000000)	60.17572 (0.000000)	3317.413 (0.000000)
Count	3443	1006	2436

6.3.2. Unit Root Tests

Figure 6.3 depicts that the spot price series of crude oil seems to be non-stationary. Further, Augmented Dickey-Fuller (ADF) and Phillips - Perron (PP) tests have been conducted in “intercept” as well as “trend and intercept" form as confirmatory tests. Table 6.5 displays the results of stationarity tests. For the log series, the p-values are greater than 0.05. So, the null hypothesis of non-stationarity cannot be rejected at 5% level of significance. However, their returns are stationary as the p-values less than 0.05. Thus, we can proceed to employ the EGARCH model.

Table 6.5: ADF and PP Test Results

Series name	**Intercept Form**		**Trend and intercept**	
	ADF	**PP**	**ADF**	**PP**
LSP (log of spot price)	-2.410988 (0.1387)	-2.447845 (0.1287)	-2.187263 (0.4960)	-2.237225 (0.4680)
RSP (log return of SP)	-63.87988 (0.0001)	-63.91363 (0.00001)	-63.88852 (0.0000)	-63.94103 (0.0000)

Note: Critical values for ADF test are -2.89 & -3.45 and that of PP test are -2.883073 & -3.44370 at 5% level of significance.

6.3.3. Analysis of Volatility in Crude Oil Spot Market using EGARCH

This study uses the EGARCH (3,3,3) model to analyze the effect of the recent GFC on the crude oil's spot market volatility. EGARCH model has been employed for the spot market log return with and without dummy. The dummy takes a value of zero for the pre-crisis period, i.e. (May 16, 2005 to September 14, 2008) and one for the post-crisis period (September 15, 2008, to 31 March, 2017). The results have been shown in Table 6.6 where α, β and γ capture ARCH, GARCH and leverage effects respectively. δ_1 represents a change in return and δ_2 represents a change in volatility due to global financial crisis 2008.

Without dummy, all the coefficients for αs, βs and γs have been found to be significant (see Table 6.6). The significant values of α, i.e., 0.124521, 0.111372 and 0.120081 suggest that ARCH effect is present in the series and three periods' lagged news about the market has an effect on the current returns. Coefficients of γ are negative and significant, i.e. -0.039916, -0.072487 and -0.066869 depicting the existence of leverage effect. It means that bad news in the previous three periods has a greater effect than good news on the current volatility of crude oil spot market. Moreover, significant positive coefficients of β, i.e. 0.462123, 0.531917 and 0.891447 represent that GARCH effect (volatility clustering) exists in the series. It implies that positive changes are followed by further positive changes and vice versa.

On introducing dummy, it is found that the coefficients δ_1 is significant with the negative sign while δ_2 is highly insignificant (see Table 6.6). It shows GFC has an effect on the spot market returns but no effect on the spot market volatility of crude oil. The possible reason for the volatility of crude in 2008 could be financialisation of commodity exchanges and overspeculation in crude oil. The similar results were found by Mayer (2010), and Till (2009), Aulerich, Irwin and Gracia (2010) and Olowe (2010). There are a few researches which study the effect of the recent GFC on the commodities market as most of the studies have been conducted on the stock market.

The results of some diagnostic tests of residuals for serial correlation and ARCH effect are also given in Table 6.6. These results indicate that this model is free from autocorrelation up to 36 lags as coefficients are found to be insignificant. Similarly, the p–values of F and chi-square tests indicate that insignificance at 5% level of significance. Thus the EGARCH model is well specified.

Table 6.6: Parameters Estimates of EGARCH model

Variable		Without Dummy		With Dummy	
		Coefficient	Prob.	Coefficient	Prob.
Mean Equation					
C		0.026805	0.3404	0.113679	0.0319
δ_1		-----	-----	-0.143239	0.0216
Variance Equation					
ω		-0.212653	0.0000	-0.214481	0.0000
α_1		0.124521	0.0000	0.125105	0.0000
α_2		0.111372	0.0000	0.110188	0.0000
α_3		0.120081	0.0000	0.118008	0.0000
γ_1		-0.039916	0.0002	-0.043079	0.0001
γ_2		-0.072487	0.0000	-0.076531	0.0000
γ_3		-0.066869	0.0000	-0.070118	0.0000
β_1		0.462123	0.0000	0.463142	0.0000
β_2		0.531917	0.0000	0.531292	0.0000
β_3		0.891447	0.0000	0.891400	0.0000
δ_2		-----	-----	0.009815	0.3327
Diagnostic Tests for Residuals					
Autocorrelation(Q-stat)		All insignificant		All insignificant	
ARCH-LM	F-stat	-----	0.1567	-----	0.1352
	Obs*R^2	-----	0.1566	-----	0.1351

Financialisation-use of commodities as an asset class-has increased after the dot-com crash in 2000. Crude oil is one of the investment commodities in the international market due to its industrial demand followed suit. Between 2002 to mid-2008, the number of futures and exchange-traded options contracts outstanding has increased by more than 300% while OTC derivative contracts increased by more than 1400%. After that, investment fell sharply and before rising again in the first half of 2009. These financial investors don't trade by fundamental market forces, i.e., demand and supply. Due to very large positions in the commodity market, they are able to influence commodity price. Crude oil volatility was found to be less from Jan 2007 to June 2008 while it was highest in early 2009 (Mayer, 2010). The spot price graph of crude oil in figure 1 also follows the same trend. Mayer (2010) provided evidence that the financialisation of commodity exchanges has led to increased price volatility in 2007-2008. Also, Aulerich et al. (2010) found that the index traders had amplified price volatility during 2006-2008. Till (2009) in his research on US oil futures concludes that there was excessive speculation in NYMEX oil futures from summer 2007 to summer of 2008.

Thus, this study concludes that the global financial crisis affected the return on crude oil spot prices but did not affect the volatility of the crude oil spot market. The possible reason for the volatility of crude in 2008 could be financialisation of commodity exchanges and excessive speculation in crude oil futures. Without dummy, the results show the presence of ARCH and leverage effects up to three lags. The results also support the presence of volatility clustering.

Thus, from the results of linkage analysis of Indian commodity futures market with international markets this study concludes that futures markets of copper and crude oil are not efficient as their market at MCX and their respective foreign futures market are cointegrated. However, the gold futures market at MCX and NYMEX are not cointegrated and hence efficient. However, the gold oil futures market at NYMEX leads MCX market.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This study analyses the efficiency and related issues like seasonality, inflationary impact, global financial crisis and its effect on spot market volatility, International linkages of the commodity futures market in India for the sample commodities (gold, crude oil, copper and chana).

7.2 Conclusions

Efficiency and Seasonality

To investigate efficiency of select futures markets, this study uses Johansen's cointegration and Granger Causality techniques for the two sub-periods i.e., the pre and the post-crisis periods. Johansen's cointegration test results report that the spot and futures prices are cointegrated for all the sample commodities. In other words, there exists a long run equilibrium between spot and futures prices of the select commodities in both the sub-periods. Causality results report that futures markets ability to predict subsequent spot prices for gold and copper is higher as compared crude oil and chana, and has improved across the periods. From the results of cointegration and causality, it is concluded that the futures market for all select commodities namely chana, gold, crude oil and copper are efficient.

To analyze seasonality, a dummy is introduced in the regression model wherein futures price is dependent variable and spot price is the independent variable. The dummy assumes value 1 for the months of season of the crop (from March to September) and 0 for off-season months (from October to February). The results of Ramsay RESET test for the given regression model shows that relationship between natural logarithmic returns on spot price and natural logarithmic returns on futures prices is linear in nature. On introducing dummy variable in the regression model, the results indicate that there is significant effect of futures returns on spot prices returns while the effect of seasonality is insignificant. It means the association between the chana spot and futures prices is not affected by the seasonality.

Macroeconomic Issue- Inflation

Toda Yamamoto modified Granger causality technique has been employed on the monthly futures volume and commodity specific WPI data. The results indicate that crude oil futures trading results in increase in prices of crude oil in spot market. However, there is no causality from futures trading volume to WPI for chana, gold and copper. In a nutshell, this study doesn't find any relationship between futures trading and inflation for three out of four select commodities. Thus, this study concludes that there is insufficient evidence to support that commodity futures trading has led to higher inflation in India.

International Linkage and Global Financial Crisis

This study employs Johansen's cointegration and Granger causality techniques to analyze the linkage and causality between the select markets. From results, this study concludes that the global financial crisis (GFC) affected the return on crude oil spot prices but did not affect the volatility of crude oil spot market. The possible reason for volatility of crude in 2008 could be financialisation of commodity exchanges and excessive speculation in crude oil futures. Without dummy, the results show the presence of ARCH and leverage effects up to three lags. The results also support the presence of volatility clustering. From the results of linkage analysis of Indian commodity futures market with international markets this study concludes that futures markets of copper and crude oil are not efficient as their market at MCX and their respective foreign futures market are cointegrated. However, the gold futures market at MCX and NYMEX are not cointegrated and hence efficient. However, the gold oil futures market at NYMEX leads MCX market.

7.3. Research Implications

This is the only study which analyses Indian commodity futures market efficiency in connection with related important aspects namely inflation, seasonality and international linkage. The results of efficiency and seasonality analysis are important for the traders, importers, corporate houses, government and policy makers. As the futures markets of sample commodities are efficient, the commercials (traders, producers, and consumers) can make use of the futures market information to hedge their price risk.

These results of analysis of nexus between inflation and commodity futures trading are relevant to the government and the market regulator for a suitable policy framework to further promote and develop commodity futures market without any apprehension about its inflationary impact. Moreover, the results are useful in building up market participants' confidence in futures trading that would further help the market grow and increase its breadth and depth.

For the last four years, domestic oil production in India has been falling due to ageing fields and non-exploration of fresh oil reserves. On the other hand, the oil consumption has been climbing up due to rise in on road and air traffic, and poor monsoon led raised diesel demand for irrigation. Given the elevating consumption and declining production of oil, India‘s dependence on imports is increasing and hence the results of the study are of critical implication for appropriate import policy formulation for Indian economy. The findings of analysis of the impact of GFC on the return and volatility of crude oil spot markets reveals that the crisis affected the return on crude oil spot prices but did not affect the volatility of crude oil spot market. It would help policy makers understand the volatility behaviour of crude oil and accordingly plan oil imports.

From the results of linkage analysis of Indian commodity futures market with international markets this study concludes that futures markets of copper and crude oil are cointegrated with their respective foreign futures market while the gold futures market are not cointegrated. These results are important to the policy makers, traders, governments and commodity exchanges of India and USA dealing with crude oil and copper futures. Commodities are used as an asset class also. The study contributes to the investment perspective of portfolio managers.

7.4. Limitations of the Study

Like any other empirical research, this study also has some limitations. These are as follows.

1. There are 113 commodities which are traded in futures market in India. But, this study is confined to four of them based on their weights in MCX’s commodity index (comdex) only due to time and resource constraints.
2. The select commodities are also traded on other national commodity exchanges in India but this study is limited to only MCX and NCDEX.
3. Although every effort has been made to fulfil the basic assumptions, research tools and techniques have their own inherent limitations. These limitations apply to this study also.

4. The study is based on secondary data taken from various commodity exchanges which may have some limitations.

7.5. Recommendations

From the results of this study, it is recommended that

1. The commodity traders, producers and consumers should be educated about the mechanics and the role of futures market in price discovery and price risk management. They should be motivated to use commodity futures to take advantage of the said functions.
2. The government should have least intervention in setting up the prices of commodities traded in futures market. This will facilitate the fair pricing of commodities.
3. In case of rise in prices of commodities traded in futures market, the efforts should be made by the government and regulators to reduce the distortion caused in its spot market prices rather than imposing a ban or suspension.
4. The linkages and causality dynamics between Indian and Foreign futures markets demand these exchanges and governments to critically analyse the policies and trade practices before implementing. This is important because these policies are going to affect the trade and hence the prices in that market which would be transmitted to the other market due to international linkage.

7.6. Scope for Future Research

1. For analyzing the efficiency and international linkages of Indian commodity futures market, high frequency data can be used.

2. For analyzing inflationary impact of commodity futures trading, a different futures trading variable like open interest and other measure of inflation like CPI can be used.

3. The effect of other macro-economic variables like GDP and Interest rate on commodity future market can be studied.

4. Commodity market microstructure in India can be explored.

5. The efficiency of commodity futures market can be analysed for other commodities and futures markets like NMCE.

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Mr Singh has participated in research projects/CEP/workshops on topics like optimization methods, quantitative finance, financial mathematics, financial modelling and risk management at institutes like IIM Calcutta, IIT Delhi, IIT Kharagpur and IGIDR Mumbai. He has completed summer research fellowship at IIT, Delhi. He has co-authored a book titled *Operations Research* for UG and PG courses for Ane Books India Publications. Another book on *Quantitative Techniques for UG* courses is in press. He has presented papers in International Conferences at IIM-Ahmedabad and IIT Delhi. His research papers have been published in *Scopus Indexed* and *ABDC listed* journals on International publication houses like *Inderscience* and *Sage*. He has also written some cases in finance for class room discussions. He has delivered FDPs on *Financial Econometrics* and *Research Methodology* at some institutes.

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LIST OF PUBLICATIONS

International Publications (6)

1. "Causality nexus between inflation and commodity futures trading in India", *International Journal of Indian Culture and Business Management*, Vol.17, No.1, 2018, pp. 1-15. **Inderscience Publication (ABDC Listed)**
2. "Crude oil market and global financial crisis - structural break and market volatility analysis", **Scopus Indexed -**Int. J. Economics and Business Research, Vol. 13, No. 2, 2017, pp 203-216. **Inderscience Publication (ABDC Listed)**
3. "Empirical Investigation on Food Inflation and Efficiency Issues in Indian Agri-Futures Market", *Emerging Economy Studies, Vol. 3, No. 2, 2017, pp 1-10* - **Sage Publications.**
4. Global Financial Crisis and Price Risk Management in Gold Futures Market- Evidences from Indian & US Markets, *The Romanian Economic Journal,* Year XXI no. 68, 2018, pp. 111-120.
5. "Review of Commodity Futures Market Efficiency and Related Issues", *Research Journal of Social Science & Management-RJSSM*, Vol. 4, No. 9 (2015): 01 Jan 2015 : pp. 262-272; **(UGC Listed)**
6. Commodity futures market efficiency and related issues: A review of existing literature. *Asian Journal of Business and Economics*, *4*(4), 2014, pp.1-21.

National Referred Journal Publications (2)

1. "Price Discovery in Crude Oil Futures Market in India", MAIMT- Journal of IT & Management, Vol. 11, No. 2, pp. 56-68, May-2018. **UGC listed**
2. "Testing Seasonality and Efficiency in Chana Futures Market", Apeejay Business Review, Vol. 14, No. 2, Dec 2015, pp. 5-15.

Paper Presented at International Conference (3)

1. "Market Efficiency and Inflationary Impact of Agricultural Futures Trading in India", 5th **International Conference** on Advanced Data Analysis, Business Analytics and Intelligence, **IIM-Ahmedabad**, April 08-09, 2017.
2. "Efficiency of Chana Futures Market in India-Johansen Cointegration Approach" presented in 6th International Conference on Contemporary Business organized by **IIT Delhi and Curtin University Australia**, at IIT Delhi, 18-20 Oct., 2012.

3. “Market Efficiency, Global Financial Crisis and Price Risk Management – An Evidence from Indian Gold Futures”, Seventeenth Global Conference on Flexible Systems Management-GLOGIFT 2017, at Delhi Technological University (DTU), Dec 11-13 2017.

Paper Presented/Published at National Conferences (2)

1. “Seasonality and Efficiency in Chana Futures Market in India - An Empirical Investigation”, 3rd Conference on Innovative Financial Practices and Developments (CIFPD- 2016) on the theme Global Financial Perspectives on 15 January, 2016, at Apeejay School of Management, Dwarka, Delhi.
2. "Testing Long Run Relationship between Futures and Spot Market in India" in the Conference on Innovative Financial Practices and Developments (CIFPD-2013) to be held on 20th December, 2013 at Apeejay School of Management, Dwarka, Delhi.