COMMODITY FUTURES MARKET IN INDIA:
AN EMPIRICAL ASSESSMENT DURING 2004-2014

DOCTOR OF PHILOSOPHY

IN

ECONOMICS

BY

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Annexure – I

Commodity Futures Market in India: An Empirical Assessment during 2004-2014

A Thesis submitted during 2015 to the University of Hyderabad in partial fulfillment of the award of a Ph.D. degree in the School of Economics

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Annexure – II

CERTIFICATE

This is to certify that the thesis entitled 'Commodity Futures Market in India: An Empirical Assessment during 2004-2014' submitted by Mr. Thota Nagaraju, bearing Regd. No. 13SEPH09, in partial fulfillment of the requirements for the award of Doctor of Philosophy in Economics is a bonafide work carried out by him under my supervision and guidance which is a plagiarism free thesis.

The thesis has not been submitted previously in part or in full to this or any other University or Institution for the award of any degree or diploma.

Signature of the Supervisor
(Prof. Bandi Kamaiah)

Dean of the School
(Prof. Bandi Kamaiah)

Annexure - III

DECLARATION

I, Thota Nagaraju, hereby declare that this Thesis entitled "Commodity Futures Market in India: An Empirical Assessment during 2004-2015" submitted by me under the guidance and supervision of Professor Bandi Kamaiah, is a bondafide research work which is also free from plagiarism. I also declare that it has not been submitted previously in part or in full to this University or any other University or Institution for the award of any degree or diploma. I hereby agree that my thesis can be deposited in Shodganga/INFLIBNET.

As per the UGC Regulations (2009) regarding the procedure for award of a Ph.D. Degree, one research paper should be published in a refereed journal before submitting the Ph.D. thesis. Two of my papers have been published in a refereed journal and the details are provided in the appendix.

Date: Name: Thota Nagaraju

Signature of the Student:

Regd. No. 13SEPH09

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CHAPTER 1

INTRODUCTORY BACKGROUND, ISSUES

AND

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1.1: Introduction

Creation of a futures market in commodities is a significant innovation in human history. The primary motivation for this innovation arose out of the simple fact that while for the primary sector production is largely seasonal and subject to several risks, consumption is not. This is true for most commodities. Essentially, the futures market provides a mechanism by which the prospects of future production and consumption are incorporated in today's price in a logical way and thus a link is established between present and future production and consumption cycles, facilitating the inter-temporal smoothing of prices. Commodity derivatives essentially play the role of stabilizing resource allocation plans over time periods by ensuring a stable price schedule at a point of time in the future.

Although the first recorded instance of futures trading may be traced to the Dojima Rice futures contracts in 17th Century Japan, formal and standardized commodity futures trading started with the establishment of the Chicago Board of Trade (1848). Commodities have been emerging as an increasingly important class of assets for institutional and individual investors in recent years. Systematic investigation of commodities as an investable asset class goes back at least some 35 years ago (Greer, 1978, Bodie and Rosansky, 1980). However, investing in commodities through futures markets has gained importance ever since the burst of the dot-com bubble. Stung by huge losses, financial investors were on the lookout for a new asset class to diversify their portfolio and reduce their risks. Also in the wake of globalization and surge in global uncertainties, financial organizations around the world were seeking methods and instruments to contain the price risk that these uncertainties bring. Commodity derivatives instruments offered the features

that these investors and institutions were looking for in the market (Erb and Harvey 2006; Gordon and Rouwenhorst, 2006). They have been devised to manage price risk by valuing the price of a security based on the value of an underlying commodity. During the past two decades, many institutional portfolio managers added commodity derivatives as an asset class to their portfolios. This resulted in a substantial growth[1] in the use of commodity derivatives that was considerably out of proportion with the historical levels associated with commercial hedging.

Though many countries did not completely ban trading in commodity futures; they have been discouraging such trade as speculative activity in the commodity futures trading could reinforce price volatility and instability in primary sector products (especially in the essential commodities) and similar is the case with India also. Trading in commodity derivatives is not new to India (it is mentioned in Kautilya's Arthashastra), but the modern day type trading in commodity futures started in 1875 with the establishment of the Bombay Cotton Trade Association. However, formal trading in commodity futures started with the establishment of the regulatory body, namely, the Forward Markets Commission (FMC) in 1953. Severe drought and commodity market manipulations which increased commodity prices in the late 1960s led to the ban on commodity forward trading in India. Based on the Khusro committee report a few selected commodities futures were reintroduced in 1980. Due to globalization pressures, the Kabra[2] and Guru Committees and the agricultural policy (2000) recommendations, the Indian government allowed trading in commodity futures by the end of 2003.

Even today, approximately 70 percent of the Indian population is still dependent on the primary sector, the average landholding size is 1.3 hectares and their annual income is less than ten thousand rupees. Moreover, the primary sector and it's inter related markets are full of information asymmetry and trading in this sector's production is highly fragmented across the country with regional commodity markets and local mandis accounting for all trading. Even the regional commodity markets are not integrated, rather, they are working pretty much in isolation. The 70 percent population dependency on the primary sector, past experience with regard to commodity futures (the l960 and 2008 commodity futures ban due to increase in prices because

[1] For example, trading in commodity futures in recent times, especially post 2000 in the USA, ("inflows into commodity investments during 2009 were recorded at $60 billion, topping $51 billion from 2006", (Wall Street Journal, January 4, 2010) and Stoll and Whaley (2010) concluded that the total investment in the commodity index was $174 billion in 2009).

[2]The Indian government set up a committee under the chairmanship of Prof. K.N.Kabra in 1993 to assess the working of the commodity exchanges in India.

of trading in commodity futures) and recent scandals (such as the Guar futures scandal 2012 and the NSEL payment scam 2013) raise many questions on the benefits (or the aim of creation) of the commodity futures for market participants (producers, processors and consumers) in terms of price discovery and risk management.

However, it has been proved in the advanced economies (especially in the USA) that efficient price discovery and risk management are realized in the commodity futures markets once they have been established as an investable class of assets in the financial industry. Though it's not a necessary condition for the commodities to become an investable class of asset to realize efficient price discovery and risk management, due to its quality of being an investable class of assets a significant amount of trading takes place (liquidity) in the commodity markets and that leads to efficient price discovery and risk management. As an investable class of assets, commodities provide valuable diversification benefits (i.e., have zero or negative correlation with stocks and bonds) and yield positive risk premium. They also act as the best hedge against rising inflation when traditional assets are performing poorly. Similarly, commodity futures reduce portfolio risk when added to a portfolio of stocks and bonds, though they are commonly viewed as a high-volatility, "high-risk" asset class on a standalone basis.

Through participation in the commodity futures markets, a commodity producer can gain in various ways. For example, a farmer can sell a crop before it planted, eliminating the price risk as well as the market risk by locking into futures contracts. On the other hand, purely as an investor (trader) he can also enhance his returns because of its investable character. Similarly, as a consumer he can eliminate price risk by locking into futures contracts. On the other hand, without participating also, commodity producers can benefit by virtue of its being an investable class of assets. Farmers (as producers and consumers) benefit indirectly from the existence of futures markets through easier access to better information about future prices, and through higher prices resulting from lower marketing and processing costs.

Due to its qualification as an asset class, the commodity futures markets deliver their ultimate benefits to market participants as well as to producers either directly or indirectly. Therefore, in this context the present study examines the Indian commodity futures from the perspective of an investable class of assets starting from their reintroduction in 2004.

1.2: Issues under Study

Trading in commodity derivatives in India dates back to 1875, where the Cotton Trade Association began futures trading. The first organized futures market, for various types of cotton appeared in 1921 and subsequently proliferated all over India. Regulated trading in commodities started after the enactment of the Forward Contract (Regulation) Act, 1952 which provided the legal framework for organized forward trading in the country and for the recognition of commodity exchanges. Severe drought and commodity market manipulations in the 1960s led to a ban on commodity forwarding trading in India which lasted till early 2003. Due to liberalization (World Bank and United Nations Conference on Trade and Development (UNCTAD)) pressures, based on the Kabra and Guru committee's recommendations and the national agricultural policy's (2000) favourable views on commodity futures trading, the Indian government lifted the ban on agricultural commodities and allowed trading in 54 commodities by setting up commodity futures exchanges in 2003 with the aim of creating a common integrated and regulated commodity futures market to enable producers (especially farmers) as well as the end users to hedge the price risk arising out of price fluctuations. However, the recent (2008) ban on four commodities (because people perceived that trading in chickpea, potato, rubber and soy oil aggravated the prices), the recent scandals (such as the Guar futures scandal, 2012 and the NSEL payment scam, 2013) and on one hand illiquidity in some commodities and on the other, huge trading activity only in few bullion, metals and agricultural markets have raised many questions on their fundamental nature[3] as an asset class.

On the other hand, recently commodity futures markets have been identified as an investable class of assets in the advanced economies because of their zero or negative correlation with stocks and bonds, the existence of a positive risk premium, their ability to act as the best hedge against rising inflation and their risk reduction capability when added to a portfolio of stocks and bonds. All these perceived benefits of commodity futures as an investable class of assets in the

[3]Though there are few studies which examined the Indian commodity futures markets in terms of evolution (Lokare, 2007; Dummu, 2009; Srivastava and Saini, 2009), efficiency (Naik and Jain, 2002; Sahadevan, 2002; Dasgupta, 2004), nature of price discovery (Kumar, 2004), the causal relationship between spot and futures prices (Dasgupta, 2004; Ali and Gupta, 2011; Sahoo and Kumar, 2011; Sendhil et al., 2013; Inoue and Hamori, 2014; and Kumar and Shollapur, 2015), and hedging effectiveness (Yaganti and Kamaiah, 2012; Aggarwal et al., 2014).

advanced countries also raises questions about whether these benefits will be realized in the Indian context or not, given their one decadal trading history in India.

In the light of the issues discussed above, the following research questions are raised:

I) As an investable class of assets, how the Indian commodity futures returns behaved compared to other asset classes in India?

II) What is the risk-return relationship in the commodity futures markets given that some of the commodity futures markets are illiquid and on the other hand highly concentrated trading occurs only in few bullion and metals markets?

III) Can the commodity futures be used as an effective hedge against inflation and its components?

IV) How volatile are the commodity futures over time and across sectors?

1.3: Objectives of the Study

Keeping in mind the issues and research questions raised, the main objectives of the study are set as follows:

I) The first objective is to examine whether the Indian commodity futures are an investable class of assets or not;

II) The second objective is to understand the risk and return relationship in the Indian commodity futures markets;

III) The third objective is to examine to what extent the Indian commodity futures are a hedge against inflation;

IV) The fourth objective is to conduct an empirical assessment of volatility in the Indian commodity futures markets.

1.4: Data and Methodology

This study utilizes all the commodity futures contracts data which are traded on the Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) from January 2004 to December 2014. The reason for focusing only on these two exchanges out

of 21 exchanges is the fact that 97 percent of trading activity takes place on these two exchanges and most of the contracts started trading from January 2004 only.

We have utilized the monthly, quarterly and annual commodity futures closing prices to construct the monthly, quarterly and yearly rebalanced equally weighted commodity futures return index. We have also utilized the wholesale price index (WPI) and 90 day T-bills data to account for inflation and expected and unexpected inflation. Similarly, we have utilized the CNX Nifty, NSE bond index and 90-day treasury bills closing prices at three frequencies (monthly, quarterly and yearly) to compare with the commodity futures equally weighted index.

In order to estimate the systematic risk component, using the modified traditional Capital Asset Pricing Model (CAPM) and consumption CAPM in the Indian commodity futures, we have utilized all the commodity futures contracts of the MCX and NCDEX, CNX Nifty monthly closing prices and India's monthly imports from January 2004 to December 2014.

To estimate the hedging effectiveness of the Indian commodity futures against inflation, and its components (expected and unexpected inflation) using regression models, we have utilized the monthly closing prices of commodity futures of the MCX and NCDEX and monthly whole sale price (WPI) index and three month treasury bills during the period from January 2004 to December 2014.

To test volatility persistence and asymmetric effects in the Indian commodity futures markets, we have employed the ARCH-GARCH methodology. More specifically, the symmetric GARCH (GARCH (1,1) and IGARCH (1,1)] and asymmetric GARCH [EGARCH (1,1) and TGARCH (1,1)] models are used. We have utilized the daily closing price of the MCX and NCDEX commodity futures from January 2004 to December 2014, to examine the issue of volatility.

1.5: Organization of the Thesis

The present study is organized in the form of six chapters. The first chapter provides the background to the study, issues and research questions, and presents the objectives, details of the data and methodology as well as scope and limitations of the study. The second chapter provides a detailed analysis of the Indian commodity futures markets as an investable class of assets at the aggregate level using the equally weighted index and then further elaborates on individual

commodities' returns performance also. Since it is proved in the second chapter that the Indian commodity futures markets are an investable class of assets, in order to ascertain the investable class of assets character at the commodity level as well as the sector level, we proceed further with the commodity wise analysis in terms of the existence of risk-return relationship, hedging properties against inflation and finally their volatility. Accordingly, the third chapter estimates the commodity wise risk and return relationship in the Indian commodity futures markets. The fourth chapter deals with an empirical analysis of commodity wise volatility. The fifth chapter provides a detailed analysis of all commodity futures and their hedging effectiveness against inflation in India, and the sixth and final chapter provides the summary of findings and concluding remarks.

1.6: Scope and Limitations of the Study

Though the present study covers only the Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) from January 2004 to December 2014, which together have covered 97 percent of trading activity, there are however, 19 more registered exchanges in India which have been excluded from this study. Similarly, there were few commodity futures contracts which traded before January 2004 but could not be included in this study. This study considers a few techniques in the estimation of commodity futures short and long term returns, systematic risk, hedging against inflation and volatility, especially asymmetric volatility estimation. One can use alternative methodologies in future research to draw more robust conclusions about Indian commodity futures as an investable class of assets in India. One can also examine the determinants and spillover of volatility of these commodity futures.

CHAPTER 2

ARE THE INDIAN COMMODITY FUTURES AN INVESTIBLE CLASS OF ASSETS OR NOT?

2.1: Introduction

Though trading in commodity futures dates back to the 17th century of the Dojima Rice futures contracts in Japan, the more formal and standardized commodity futures trading started with the establishment of the Chicago Board of Trade (1848). However it's recent academic research which has begun highlighting the merits of the commodity futures as an alternative investible class of assets due to their low or negative correlations with traditional asset classes such as equity and bonds. Their low or negative correlation with traditional asset classes, inflation-hedging ability, no short sale restrictions and the ability to trade at organized exchanges with low transactions costs have made commodity futures become more widespread investment vehicles among all the investible class of assets. Compared to direct or indirect investment in commodity based stocks and fixed income products, direct investment in the commodity futures also offers significant diversification benefits to Owing to all these characteristics, commodity futures are being used in tactical and strategic asset allocations.

The unacceptable levels of volatility in the equity and bond markets and possible resurgences in inflation in recent periods (early 2000 and especially the onset of the recent 2007-08 financial crisis) led to strong growth in the commodity futures markets. Based on the Barclay hedge updates, the World Bank commodity outlook[4] reports that the average assets under management in commodities from 2011 to 2014 were around $320 billion after touching an all-time record of the amount $420 billion as on March 2011 (as reported by Carpenter, 2011 and Belousova and Dorfleitner, 2012). Once again these numbers, in terms of total value of the investments and inflows into the commodity futures, highlights the nature of the commodity futures as an alternative investible class of assets given their returns characteristics (such as low correlations and hedging ability, etc.) with the returns of the traditional (such as equity and bonds) investible class of assets. Several reasons can be attributed to this phenomenon, the most prominent one

[4]http://www.worldbank.org/content/dam/Worldbank/GEP/GEPcommodities/commodity_markets_outlook_2014_october.pdf

being that the drivers of commodities prices are different from those of stock and bond prices. In the former case it is the demand and supply, weather, geopolitical conditions, and event risk (Daskalaki and Skiadopoulos, 2011) and in the latter case it is the fundamentals along with macroeconomic situations that determine prices.

Due to their own useful characteristics and merits as an investible class of assets and also as an alternative investible class of assets (the recent investment boom in the commodity futures in the developed countries confirms this feature) compared to the traditional investible class of assets, trading in commodity futures in India provides us an opportunity to explore whether the aforementioned merits and characteristics hold or not. In other words, we examine the nature of the Indian commodity futures markets from an investible class of assets perspective compared to the traditional investible class of assets.

The remainder of the chapter is organized as follows: section 2 presents the relevant literature review, section 3 describes data and methodology, section 4 reports the empirical results and discussion and section 5 presents the conclusion.

2.2: Literature Review

There exists a substantial body of literature which has examined the nature of commodity futures returns from various perspectives. Greer (1978) advocated commodities as a strategic investment for institutions. Using quarterly data between 1950 and 1976, Bodie and Rosansky (1980) constructed an equally-weighted index and found that the mean return on both the benchmarks of commodities and common stocks were more or less the same. They also reported that when equities are doing badly, the commodities do well and vice versa. Another important finding was that switching from a pure equity portfolio to a composition of 60 percent equity and 40 percent commodity portfolio reduces the return variability by one third without compromising any returns and commodity futures proved to be a very good inflation hedge during their sample period. Fama and French (1987) examined two models of commodity futures prices (theory of storage and forecast power and premium) for 21 commodities and for the first model they found that basis varies due to interest rate change and seasonality in the convenience yield. For the second model they showed evidence of forecast power for ten commodities and for five commodities, time varying expected premiums. Ankrim and Hensel (1993) studied the

diversification benefits of investing in commodities over the period 1972–1990, and concluded that for any given risk tolerance coefficient, expanding the optimal portfolios with commodities improves the risk-return trade-off. Satyanarayan and Varangis (1996) examined whether the efficient frontier changes when commodity futures are incorporated into international asset universes over the period 1970–1992. They found that the inclusion of commodities shifts the efficient frontier upwards. Similarly, Abanomey and Mathur (1999) also confirmed that efficient frontier shifts upwards due to the inclusion of commodities in the optimal portfolio during the period 1970 to 1995.

Greer (2000) studied a commercially available index between 1970 and 1999 and found that the unleveraged commodity index total return was positive and its average return and volatility were comparable with equity returns. Commodity index returns were negatively correlated with bonds and equity. On the other hand, commodity index returns were found to be positively correlated with inflation and changes in the inflation rates. The advantage of studying commodities at the portfolio level is that diversification helps to reduce the noise that is inherent in individual commodities. Jensen et al. (2000) showed that during the restrictive monetary policy period commodity futures have a substantial weight in efficient portfolios compared to expansive monetary policy with significant return enhancement at all levels of risk. Georgiev (2001) concludes that switching from pure stock portfolio to a portfolio with stocks and commodities over the period 1995–2005 can increase the portfolio's Sharpe ratio. Gorton and Rouwenhorst (2006) also constructed the monthly equally weighted commodity futures index to study the nature of the commodity futures as an asset class for the sample period July 1959 to December 2004. Their study found that during the sample period, equities and commodity futures offered the same returns, risk premium and Sharpe ratios. They also found that commodity futures have a negative correlation with equities and bonds; however they are positively correlated with inflation, unexpected inflation, and changes in expected inflation. The recent portfolio diversification studies (Woodard, 2008; Marshallet al. 2008; Cao et al., 2010; Chung and Miu, 2010; Conover et al. 2010; Galvani and Plourde, 2010; Daskalaki and Skiadopoulos, 2011; Belousova and Dorfleitner, 2012 and Huang and Zhong, 2013) document the benefits of commodity futures inclusion in the portfolio.

2.3: Data and Methodology

To investigate the short and long-term returns of commodity futures, we construct an equally weighted performance index of commodity futures at the monthly, quarterly and yearly frequencies. The reason for focusing on the equally weighted commodity futures index is that by analyzing the equally weighted commodity futures index, we can address the following questions - "How does the average commodity futures behave during the average time period?" and "How does the change in frequency influence the performance index?". In the following sections we analyze the index returns and observe how they are influenced by the monthly, quarterly and annual frequency rebalancing. At the same time, we also analyze the commercially available aggregate and sector specific commodity futures indexes.

We utilize the data maintained by the National Commodity & Derivatives Exchange Ltd. (NCDEX) and Multi Commodity Exchange of India Ltd. (MCX) for the construction of an equally weighted index, which consists of the closing prices of individual futures contracts since 2004. Our index is free from selection and survivorship biases. We overcome both the biases due to the fact of data availability on both the exchanges during the period 2004 to 2014. Many of the contracts that were introduced during the sample period, but failed to survive are also included in the index. To obtain a more detailed picture we constructed two different types of equally weighted indexes.

The first type of equally weighted index includes all the commodity futures contracts which have traded on either the MCX or NCDEX during the sample period and this avoids the exclusion as well as the survivorship biases. Sometimes, one (or the same) commodity will be trading on both the exchanges, in this case we include only one contract from either of the exchanges, whichever has the highest liquidity on an average and this avoids double counting. On the other hand, the second type of equally weighted index includes only the commodity futures contracts which survived and were traded on either of the exchanges until December 2014. This second type of equally weighted index suffers from survivorship bias. For example, let say, a commodity futures contract namely, XYZ started trading on either of the exchanges, or on both, from January 15th, 2008 and stopped trading on either of the exchanges or on both from June 30, 2012. This XYZ

commodity futures contract is included in the first type of equally weighted index but excluded from the second type of equally weighted index. Finally, for each commodity contract, there are multiple contracts listed that differ by maturity. In each month, quarter and year we select the contract with the nearest expiration date for our index, unless the contract expires in that month, quarter and year in which case we roll into the next contract. In each month, we therefore hold the shortest futures contract that will not expire in that month.

The equally weighted performance index is constructed in the following manner: at the beginning of every month we assume that the investor holds X (this X could be anything) amount of rupees in each commodity futures contract. All these commodity futures contracts are held until the end of the month, at which time the investor rebalances the index into an equally weighted index. This enables us to determine "how does the average commodity futures behave during the average time period?" For the purpose of our study we have drawn data from the National Commodity and Derivatives Exchange (NCDEX) and Multi Commodity Exchange (MCX). The reason for focusing only on these two exchanges is that they constitute about 96.19 [5]percent of the total commodity futures market in India. The sample period starts from 1st January 2004 to 31st December 2014. Our full sample consists of 132 different commodity futures from the MCX and 142 different commodity futures from NCDEX.

The number of commodity futures contracts varies from monthly to quarterly and then to yearly. For example, one commodity futures contract could have traded for less than six months, in that case it is included in the monthly equally weighted index but not in the quarterly as well as the yearly frequency. In order to include in the quarterly equally weighted index, a commodity futures must be traded for at least two consecutive quarters otherwise it will not be included in the index. Similarly, in order to include in the yearly equally weighted index, a commodity futures must be traded for at least two consecutive years otherwise it will not be included in the index. Both these exchanges maintain all the commodity futures that have been traded in the form of daily bhavcopies.

Two steps are followed in the construction of the equally weighted index: first, commodity wise, we calculate the price return on every commodity futures contract using the nearest contract that

[5]Forward Market Commission Annual Report (2013-14).

does not expire in that month. In terms of the mechanics, on the last trading day of the month prior to the expiration date of a futures contract we roll into the nearest futures contract. Second, using monthly returns for each commodity futures contract, we construct the index by adding the monthly returns together each month and dividing by the number of commodities in the index that month. For example, if there are ten commodity futures contracts traded, then we add all the ten futures returns and divide it by ten. A commodity enters the index on the last trading day of the month following its introduction date. This corresponds to monthly rebalancing. Futures returns are calculated by assuming that investors hold the nearest contract up to one month before maturity and then roll their position to the second nearest contract, where the rolling takes place to avoid physical delivery of the underlying commodity. A similar pattern is followed in the quarterly frequency and also in the yearly frequency.

Equations (2.1) and (2.2) have been used to calculate the arithmetic and geometric average returns, for more details see Roll (1983) and Gorton and Rouwenhorst (2006). For simplicity we assume that all commodity futures contracts exist at all times. Suppose M commodity futures each exist for T months, where R_{it} is one plus the return on a collateralized commodity future 'i' during month't'.

The arithmetic average return on a monthly rebalanced portfolio over the T months is:

$$\overline{R_{AR}} = \frac{1}{MT}\sum_i \sum_t R_{it} = \frac{1}{T}\sum_t \left[\frac{1}{M}\sum_i R_{it}\right] \qquad (2.1)$$

The geometric average return on a monthly rebalanced portfolio over the T months is:

$$\overline{R_{GR}^{T}} = \left[\prod_t \left(\frac{1}{M}\sum_i R_{it}\right)\right]^{\frac{1}{T}} \qquad (2.2)$$

Though one can calculate the collateralized returns (by adding the T-Bills interest to the commodity futures returns) but here the aim of the chapter is to focus solely on the performance of commodity futures without mingling them with the performance of Treasury bills.

2.4.1: Historical Returns on Commodities Futures

In this section we compare the monthly, quarterly and yearly re-balanced nominal and inflation adjusted equally weighted commodity futures index returns with other assets classes such as equity, bonds and inflation. We also compare them with the commercially available commodity futures indexes. Since the arithmetic returns are just a series of simple returns, in order to encapsulate the overall compounded investor returns into a single number we also report the geometric returns.

Table 2.1: Monthly, Quarterly and Yearly Re-balanced Average Annualized Commodity Futures Indexes Returns 2004 to 2014

Index	Distribution	All Contracts					
		Nominal			Real		
		M	Q	Y	M	Q	Y
EWI1	AM	15.75	13.80	15.09	9.11	7.72	8.56
	GM	14.81	12.76	14.07	8.31	6.68	7.42
	Sharpe Ratio	0.18	0.38	0.76	0.05	-0.12	0.34
MCX1	AM	12.73	10.93	14.25	6.31	4.97	7.73
	GM	11.88	10.03	13.22	5.54	4.09	6.62
	Sharpe Ratio	0.13	0.32	0.71	-0.01	0.10	0.30
NCDEX1	AM	12.11	11.53	15.02	5.72	5.6	8.39
	GM	11.35	10.74	14.32	5.04	4.76	7.66
	Sharpe Ratio	0.12	0.37	0.92	-0.02	0.13	0.42
		Commodity Futures Contracts Survived Until December 2014					
EWI2	AM	14.25	11.63	15.55	7.69	5.69	9.08
	GM	12.69	10.19	13.63	6.31	4.25	7.01
	Sharpe Ratio	0.12	0.01	0.57	0.02	-0.16	0.28
MCX2	AM	13.69	11.45	13.63	7.18	5.48	7.20
	GM	12.35	10.10	11.81	5.99	4.16	5.30
	Sharpe Ratio	0.12	0.28	0.51	0.01	0.10	0.21
NCDEX2	AM	9.78	9.96	11.92	3.51	4.06	5.54
	GM	8.61	8.59	11.39	2.46	2.73	4.90
	Sharpe Ratio	0.06	0.23	0.79	-0.06	0.06	0.22

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; EWI2 Stands for Equally Weighted Index and is constructed on the basis of the criterion that the commodities futures contracts existed until December 2014 and traded on either of the exchanges; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on MCX; MCX2 stands for Multi Commodity Exchange of India Ltd, which includes only the commodity futures contracts which survived and traded until December 2014 on the MCX; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; NCDEX2 stands for National Commodity & Derivatives Exchange Limited, which includes only the commodity futures contracts which survived and traded until December 2014 on the NCDEX; AM stands for arithmetic mean; GM stands for geometric mean. Nominal stands for returns not adjusted for inflation and Real stands for returns adjusted for inflation; Returns are in percentages.

Table 2.2: Monthly, Quarterly and Yearly Average Annualized Commercial Indexes Returns 2004 to 2014

Nominal (Not Adjusted for Inflation)										
Measure		Nifty	Bonds	Dhaanya	Comdex	Agri	Energy	Metal	T-bill	Inflation
AM	M	18.54	4.53	22.65	8.88	8.15	5.82	14.5	6.04	6.69
	Q	18.87	4.50	22.84	8.58	11.82	11.68	22.06	5.76	2.19
	Y	20.43	4.49	25.46	7.81	6.54	5.20	11.88	6.21	2.72
GM	M	14.95	4.33	14.53	6.00	4.71	1.62	10.5	6.01	6.65
	Q	15.43	4.22	14.13	5.25	8.19	4.12	16.21	5.71	1.28
	Y	14.43	4.26	14.19	4.58	3.72	0.76	7.98	6.18	2.72
Sharpe Ratio	M	0.12	-0.09	0.21	0.03	0.01	-0.01	0.10		
	Q	0.31	0.15	0.39	0.14	0.22	0.13	0.37		
	Y	0.52	0.26	0.92	0.23	0.18	0.08	0.41		
Real (Adjusted for Inflation)										
AM	M	11.89	-1.30	15.59	2.55	2.02	-0.42	7.88		
	Q	12.59	-1.20	15.63	2.11	5.29	4.84	14.63		
	Y	13.92	-1.66	17.59	1.54	0.34	-0.89	5.37		
GM	M	8.44	-1.58	9.71	0.72	-0.51	-3.45	4.99		
	Q	9.06	-1.53	9.09	-0.19	2.58	-1.27	10.19		
	Y	7.73	-1.84	9.51	-0.55	-1.38	-4.19	2.67		
Sharpe Ratio	M	0.06	-0.30	0.12	-0.07	-0.06	-0.08	0.01		
	Q	0.19	-0.20	0.25	0.00	0.07	0.04	0.25		
	Y	0.33	-0.73	-0.87	-0.06	-0.12	-0.13	0.12		

Note: Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market; Bonds is the NSE bond total return index; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform; Comdex is the MCX's composite commodity futures price index; Agri is the MCX's agricultural sector commodity futures price index; Energy is the MCX's energy sector commodity futures price index; Metal is the MCX's metal sector commodity; T-Bill is the three month treasury bills; bonds returns are calculated from NSE Bond total return index; Inflation percentage change in the Whole sale price index (2010 is the base year); M stands for monthly frequency; Q stands for quarterly frequency; Y stands for yearly; AM stands for arithmetic mean; GM stands for geometric mean. Nominal stands for returns not adjusted for inflation and Real stands for returns adjusted for inflation; Returns are in percentages.

Table 2.1 summarizes the two types of equally weighted indexes' (indexes which are constructed using all the contracts such as EWI1 (includes both MCX and NCDEX exchanges contracts), MCX1 (includes only MCX contracts), NCDEX1 (includes only NCDEX contracts); indexes which are constructed using only the contracts survived until December 2014 such as EWI2 (includes both MCX and NCDEX exchanges contracts), MCX2 (includes only MCX contracts) and NCDEX2 (includes only NCDEX contracts)) monthly, quarterly and yearly re-balanced nominal (not adjusted for inflation), real (inflation adjusted) arithmetic as well as geometric average annualized returns and risk adjusted (Sharpe ratio) returns from January 2004 to December 2014. Similarly, table 2.2 summarizes nominal and inflation adjusted monthly, quarterly and yearly annualized commercially available indexes (NCDEX's Dhaanya, MCX's Comdex, agriculture, energy, metal, equity index (nifty), bonds total return index, three month treasury bill yields, and inflation) arithmetic and geometric mean returns and risk adjusted (Sharpe ratio) returns from January 2004 to December 2014.

From tables 2.1 and 2.2 and figures 2.1 to 2.6, the following can be inferred,

i) All three equally weighted monthly re-balanced nominal (not adjusted for inflation) commodity futures indexes' arithmetic (i.e. EWI1 15.75 percent, MCX1 12.73 percent and NCDEX1 12.11 percent) and geometric (EWI1 14.81 percent, MCX1 11.88 percent, NCDEX1 11.35 percent) mean returns are lower than equity's (nifty 18.54 and 14.95 percent) nominal arithmetic and geometric mean returns respectively. Similarly, the inflation adjusted equally weighted commodity futures indexes arithmetic (EWI1 9.11 percent, MCX1 6.31 percent and NCDEX1 5.72 percent) and geometric (EWI1 8.31 percent, MCX1 5.54 percent and NCDEX1 5.72) mean returns are also lower than the equity's (Nifty 11.89 and 14.95 percent) arithmetic and geometric mean returns respectively. However, all three equally weighted monthly re-balanced nominal (not adjusted for inflation) commodity futures indexes' arithmetic (EWI1 15.75 percent, MCX1 12.73 percent and NCDEX1 12.11 percent) and geometric (EWI1 14.81 percent, MCX1 11.88 percent, NCDEX1 11.35 percent) mean returns are higher than bonds (4.53 percent and 4.33 percent), Treasury bills (6.04 percent and 6.01 percent), inflation (6.69 percent and 6.65 percent), Comdex (8.88 percent and 6 percent), Agriculture (8.15 percent and 4.71 percent), Energy (5.82 percent and 1.62 percent) and Metal (14.50

percent and 10.50 percent) arithmetic and geometric mean returns respectively except Dhaanya (22.65 percent and 14.53 percent) (where Dhaanya index returns are much higher than equity returns also).

Similar to the nominal returns, the inflation adjusted monthly re-balanced equally weighted commodity futures indexes are also out performed in terms of the arithmetic mean (EWI1 9.11 percent, MCX 16.31 percent and NCDEX 15.72 percent) as well as in terms of the geometric mean returns (EWI 18.31 percent, MCX 15.54 percent, NCDEX 15.04 percent) compared to bonds (-1.30 percent and -1.58 percent), Comdex (2.55 percent and 0.72 percent), Agriculture (2.02 percent and -0.51 percent), Energy (-0.42 percent and -3.45 percent) and Metal (7.88 percent and 4.99 percent) arithmetic and geometric mean returns (except Dhaanya (15.59 percent and 9.71 percent)). Similar to the nominal returns, the inflation adjusted returns also found to underperform compared to equity (nifty, 11.89 percent and 8.44 percent) in terms of arithmetic as well as geometric mean returns respectively.

ii) Similarly, all three equally weighted quarterly re-balanced nominal (not adjusted for inflation) commodity futures (which include all the contracts) indexes' arithmetic (i.e. EWI1 13.80 percent, MCX1 10.93 percent and NCDEX1 11.53 percent) and geometric (EWI1 12.76 percent, MCX1 10.03 percent, NCDEX1 10.74 percent) mean returns are lower than equity's (nifty 18.87and 15.43 percent) nominal arithmetic and geometric mean returns respectively. This is true even in the case of inflation adjusted returns also. Inflation adjusted equally weighted commodity futures indexes' arithmetic (EWI 17.72 percent, MCX 14.97 percent and NCDEX 15.60 percent) and geometric mean returns (EWI 16.68 percent, MCX 14.09 percent and NCDEX 14.76 percent) are lower than the equity (Nifty 12.59 and 9.06 percent) arithmetic as well as geometric mean returns respectively. Similar to the monthly re-balanced frequency, all three equally weighted quarterly re-balanced nominal (not adjusted for inflation) commodity futures indexes' returns are higher than bonds (4.50 percent and 4.22 percent), Treasury bills (5.76 percent and 5.71 percent), inflation (2.19 percent and 1.28 percent), Comdex (8.58 percent and 5.25 percent), Agriculture (11.82 percent and 8.19 percent) and Energy (11.68 percent and 4.12 percent) arithmetic and geometric nominal mean returns respectively (except Dhaanya (22.84 percent and 14.13 percent) and metal (22.06 percent and 16.21 percent)).

Similar to the nominal returns, inflation adjusted equally weighted commodity futures indexes also out performed in terms of the arithmetic (EWI 17.72 percent, MCX 14.97 percent and NCDEX 15.60 percent) and geometric (EWI 16.68 percent, MCX 14.09 percent, NCDEX 14.76 percent) mean returns compared to bonds (-1.20 percent and -1.53 percent), Comdex (2.11 percent and -0.19 percent), Agriculture (5.29 percent and 2.58 percent) and Energy's (4.84 percent and -1.27 percent) arithmetic and geometric mean returns respectively (except Dhaanya (15.63 percent and 9.09 percent) and metal (14.63 percent and 10.19 percent)) and underperforming when compared to equity (nifty, 12.59 percent and 9.06 percent) in arithmetic and geometric mean returns also.

iii) Similar to the monthly, quarterly re-balanced frequency, in the yearly re-balanced frequency also, all the three equally weighted nominal (not adjusted for inflation) commodity futures (which includes all the contracts) indexes' arithmetic (i.e. EWI1 15.09 percent, MCX1 14.25 percent and NCDEX1 15.02 percent) mean as well as geometric (EWI1 14.07 percent, MCX1 13.22 percent, NCDEX1 14.32 percent) mean returns are lower than equity's (nifty 20.43and 14.43 percent) arithmetic and geometric mean returns. This is true even in the case of inflation adjusted returns. Inflation adjusted equally weighted commodity futures indexes arithmetic (EWI 18.56percent, MCX 17.73 percent and NCDEX 18.39 percent) and geometric (EWI 17.42percent, MCX 16.62 percent and NCDEX 17.66 percent) mean returns are lower than equity's (nifty 13.92 and 7.73 percent) arithmetic and geometric mean returns. However, all three equally weighted yearly re-balanced nominal (not adjusted for inflation) commodity futures indexes' arithmetic and geometric returns are higher than bonds (4.49 percent and 4.26 percent), Treasury bills (6.21 percent and 6.18 percent), inflation (2.72 percent and 2.72 percent), Comdex (7.81 percent and 4.58 percent), Agriculture (6.54 percent and 3.72 percent), Energy (5.20 percent and 0.76 percent) and Metal's (11.88 percent and 7.98 percent) arithmetic and geometric nominal returns except Dhaanya (25.46percent and 14.19percent), where Dhaanyas' returns are much higher than equity returns. The yearly re-balanced inflation adjusted equally weighted commodity futures indexes also out performed in terms of arithmetic (EWI 18.56 percent, MCX 17.73 percent and NCDEX 18.39 percent) mean as well as in terms of geometric (EWI 17.42 percent, MCX 16.62 percent, NCDEX 17.66 percent) mean returns compared to bonds (-1.66 percent and -

1.84 percent), Comdex (1.54 percent and -0.55 percent), Agriculture (0.34 percent and -1.38 percent) and Energy's (-0.89 percent and -4.19 percent) arithmetic and geometric mean returns respectively (except Dhaanya (17.59 percent and 9.51 percent) and Metal (14.63 percent and 10.19 percent)). Once again, similar to the monthly and quarterly frequency, the yearly re-balanced equally weighted commodity futures indexes underperformed compared to equity (nifty, 13.92 percent and 7.73 percent) in terms arithmetic as well as geometric mean returns respectively.

iv) The second type of equally weighted monthly, quarterly and yearly re-balanced commodity futures indexes (EWI2 14.25 percent, 11.63 percent and 15.55percent), MCX2 (13.69 percent, 11.45 percent and 13.63 percent) NCDEX2 (9.78 percent, 9.96 and 11.92 percent), which are constructed using the commodity futures contracts which survived until December 2014 are also found to be outperforming bonds (4.53 percent, 4.50 percent and 4.49 percent), Treasury bills (6.04 percent,5.76 percent and 6.21 percent) and inflation (6.69 percent, 2.19 percent and 2.72 percent) respectively in terms of nominal arithmetic mean returns and a similar pattern holds in the inflation adjusted returns also in all three frequency re-balancing. However, when we compare them with the equity returns (18.54 percent, 18.87 percent and 20.43 percent), they are underperforming in all the three frequency re-balancing and in the case of the inflation adjusted series also. This means, the second type of equally weighted commodity futures indexes are exactly equivalent in terms of performance with the first type of equally weighted commodity futures indexes.

v) The comparison between the two types of equally weighted monthly, quarterly and yearly re-balanced indexes (the first one includes all the commodity futures contracts and the second one includes only the commodity futures which survived until December 2014) reveals that the first type combined exchanges (MCX and NCDEX) index namely EWI1 offers on an average 1.5 percent in the case of monthly re-balanced frequency, 2.5 percent in the quarterly frequency higher returns. On the other hand, in the case of the yearly re-balanced frequency the difference in the arithmetic series is -0.46 percent, whereas in the geometric series it is 0.45 percent. A similar pattern holds in the case of the inflation adjusted series also. Similarly, exchange wise an analysis of the two types of equally weighted indexes indicates that in the case of the MCX (-0.96 percent, -0.52

percent and 0.62 percent) the difference is negative at the monthly and quarterly frequency. On the other hand, in the case of the NCDEX (2.33 percent, 1.57 percent and 3.10 percent) the difference is positive at all the three frequencies respectively. Effectively it indicates that there exists a survivorship bias in the commodity futures returns.

vi) The Sharpe ratio of the monthly, quarterly and yearly equally weighted nominal commodity futures indexes (EWI1 (0.18 percent, 0.38 percent and 0.76 percent), MCX1 (0.13 percent, 0.32 percent and 0.71 percent) and NCDEX1 (0.12 percent, 0.37 percent and 0.92 percent)) is higher than equity (0.12 percent, 0.31 percent and 0.52 percent) and bonds (-0.09 percent, 0.15 percent and 0.26 percent) respectively. However, the inflation adjusted equally weighted commodity futures indexes' Sharpe ratio of EWI1 (0.05 percent, -0.12 percent and 0.34 percent), MCX1 (-0.01 percent, 0.10 percent and 0.30 percent) and NCDEX1 (-0.02 percent, 0.13 percent and 0.42 percent) are lower than equity (nifty (0.06 percent, 0.19 percent and 0.33 percent)) in the monthly and quarterly re-balanced frequency but higher in the case of yearly re-balanced frequency. Similarly, the equally weighted indexes Sharpe ratios are much higher than bonds (-0.30 percent, -0.20 percent and -0.73 percent) in all the three frequencies of re-balancing. This indicates that the nominal equally weighted monthly, quarterly and yearly rebalanced commodity futures indexes offer higher risk adjusted returns compared to equity and bonds. In the case of the inflation adjusted return series, the equally weighted monthly and quarterly offer lower returns but the yearly re-balanced equally weighted commodity futures indexes offer higher risk adjusted returns.

vii) The Sharpe ratio analysis indicates that as the equally weighted commodity futures indexes re-balancing frequency changes from monthly to quarterly and then to yearly, the risk adjusted returns increases. On an average, the equally weighted commodity futures indexes offer much higher risk adjusted returns compared to all other investible classes of assets.

viii) Among the commercially available commodity futures indexes (Dhaanya, Comdex, agriculture, energy and metal) only the Dhaanya index is out performing compared to all the other commercial indexes in both nominal (arithmetic and geometric mean returns) and real (arithmetic and geometric mean) returns. Though Comdex,

Agriculture, Energy and Metal are offering lower returns compared to equity but compared to bonds, Treasury bills and inflation, they are offering much higher returns in terms of nominal (arithmetic and geometric) as well as in terms of real (arithmetic and geometric) returns. A similar pattern holds in the case of the Sharpe ratios also.

ix) The comparison between commercially available commodity indexes with other investible asset class indexes reveals that they are similar to monthly, quarterly and yearly re-balanced equally weighted commodity futures indexes except Dhaanya index (where Dhaanya is offering highest returns irrespective of the return, frequency of rebalancing, distribution type and inflation adjustment) and quarterly re-balanced Metal index in terms of nominal as well as real returns. However, these commercially available commodity futures indexes (except three frequencies of Dhaanya and quarterly Metal index) returns are much lower than the monthly, quarterly and yearly re-balanced equally weighted commodity futures indexes. Though these commercially available indexes are started much later but even with their starting period analysis (such as June 2005 for MCX commercially available indexes and January 2007 Dhaanya) also reveals more or less same results. This finding indicates that on the whole, equally weighted indexes returns are superior to the commercially available indexes with the exception of Dhaanya.

The above observations can be summarized as follows. The equally weighted monthly rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index returns are lower by approximately 3 percent of the equity index returns and this gap increases by approximately 6 percent if we go by exchange wise equally weighted commodity futures indexes. This is true in the case of the arithmetic and geometric distribution also. However, the equally weighted commodity index beats bonds by 11 percent and Treasury bills and inflation by 9 percent. Among the commercially available commodity futures indexes, NCDEX's Dhaanya is beating the equities by 4 percent, bonds by 18 percent, Treasury bills and inflation by 16 percent. On the other hand, the other commercially available commodity futures indexes' returns are much lower than the equally weighted commodity futures index, but they are also beating the Treasury bills, bonds and inflation. The second type of equally weighted commodity futures indexes (constructed using only the contracts which survived until December 2014) are also found to be outperforming the bonds, Treasury bills and inflation but underperforming compared to equity. Indexes which are constructed based on all contracts are

found to be yielding higher returns in terms of the nominal (arithmetic and geometric) as well as real (arithmetic and geometric) returns compared to indexes which are constructed based on the survived until December 2014 criterion. Exchange wise analysis indicates that NCDEX's first type (based on all contracts) index is offering higher returns compared to the second type (based on the contracts survived until December 2014 criterion), but this relationship is the opposite in the case of the MCX equally weighted index. The average returns of monthly equally weighed rebalanced commodity futures returns are lower than that of equities but they are found to be offering the highest risk adjusted returns for the sample period. This gives a clear idea that at the monthly frequency, there is a survivor and exclusion bias in the Indian commodity futures markets.

Similarly, the equally weighted quarterly rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index is lower on an average by approximately 5.5 percent of the equity index and this gap increases by approximately 8 percent if we go by exchange wise indexes. This is true in the case of the arithmetic and geometric distribution also. However, the equally weighted commodity index beats the bonds by 9 percent and Treasury bills by 8 percent and inflation by 11 percent on an average. Among the commercially available commodity futures indexes, NCDEX's Dhaanya and MCX's Metal are found to be beating the equities by 4 percent, bonds by 18 percent, Treasury bills by 17 percent and inflation by 20 percent. On the other hand, the other commercially available commodity futures indexes' returns are much lower than the equally weighted commodity futures index, but they are also beating the Treasury bills, bonds and inflation. The second type of equally weighted commodity futures indexes (constructed using only the contracts which survived until December 2014) are also found to be outperforming the bonds, Treasury bills and inflation but underperforming compared to equity. Indexes which are constructed based on all contracts are found to be yielding higher returns in terms of nominal (arithmetic and geometric) as well as real (arithmetic and geometric) returns compared to indexes which are constructed based on the survived until December 2014 criterion. Exchange wise analysis indicates that NCDEX's first type (based on all contracts) index is offering higher returns compared to the second type (based on the contracts survived until December 2014 criterion), but this relationship is opposite in the case of the MCX equally weighted index. Similar to the monthly frequency, the quarterly frequency also conveys the same thing in terms of the return performance pattern. This gives a clear idea that even at the quarterly

frequency commodity futures returns are once again lower than equity but higher than bonds, Treasury bills and inflation. The wider gap between two types of the equally weighted commodity futures indexes once again shows that there is a survivor and exclusion bias in the Indian commodity futures markets.

Once again, the equally weighted annually rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index is lower on an average by approximately 5 percent of the equity indexes and this gap remains the same by approximately 5 percent even if we go by exchange wise indexes also and this is in contrast to the monthly and quarterly frequencies, where the gap used to be very large. This is true in the case of the arithmetic and geometric returns distribution also. The equally weighted commodity index beats the bond by 11 percent and Treasury bills 9 percent and inflation by 13 percent on an average. Among the commercially available commodity futures indexes, NCDEX's Dhaanya is beating the equities by 5 percent, bonds by 21 percent, Treasury bills by 19 percent and inflation by 23 percent.

On the other hand, the other commercially available commodity futures indexes 'returns are much lower than the equally weighted commodity futures index, but they are also beating the Treasury bills, bonds and inflation. The second type of equally weighted commodity futures indexes (constructed using only the contracts which are survived until December 2014) also found to be outperforming the bonds, Treasury bills and inflation but underperforming compared to equity. Indexes which are constructed based on all contracts are found to be yielding lower returns in terms of nominal (arithmetic and geometric) as well as real (arithmetic and geometric) returns compared to indexes which are constructed based on the survived until December 2014 criterion and this is in contrast to the monthly and quarterly frequency. Exchange wise analysis indicates that NCDEX's first type (based on all contracts) index is offering higher returns compared to the second type (based on contracts survived until December 2014) and similar is the case with MCX's equally weighted index, however it is exactly opposite to the monthly and quarterly frequencies. The average returns of annually equally weighed rebalanced commodity futures are lower than that of equities but they are found to be offering the highest risk adjusted returns for the sample period. Similar to the monthly and quarterly frequency, the yearly re-balanced frequency also conveys the same thing in terms of return performance pattern. This gives a clear idea that even at the yearly frequency commodity futures returns are once again

lower than equity but higher than bonds, Treasury bills and inflation. The wider gap between the two types of the equally weighted commodity futures indexes once again shows that there is a survivor and exclusion bias in the Indian commodity futures markets.

On the whole, we can say that the equally weighted rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index returns are lower than that of the equity index and this gap increases as we change the frequency from monthly to quarterly and then to yearly. On the other hand, the equally weighed index is outperforming the bonds, Treasury bills and inflation. Similarly, exchange wise equally weighted commodity futures indexes analysis also indicates the same performance pattern just like the combined exchanges equally weighted commodity futures index. The performance of the commercially available commodity futures indexes (such as MCX's Comdex, Agriculture, Energy and Metal) other than Dhaanya, are similar to the equally weighted commodity futures index compared to other asset classes. However, these commercially available commodity futures indexes' returns are far below the equally weighted commodity futures index at all three frequencies.

Equally weighted commodity futures which are constructed based on all contracts are found to be yielding higher returns in terms of nominal (arithmetic and geometric) as well as real (arithmetic and geometric) returns compared to indexes which are constructed on the basis of the criterion that the contracts survived until December 2014. Exchange wise analysis indicates that NCDEX's first type (based on all contracts) index is offering higher returns compared to the second type, but this relationship is opposite in the case of the MCX equally weighted index at the monthly and quarterly frequencies. So on an average; the equally weighted commodity futures returns (irrespective of the re-balancing frequency) are lower than equities but higher than bonds, Treasury bills and inflation. However, they are found to be offering the highest (based Sharpe ratios) risk adjusted returns for the sample period in all three re-balancing frequencies. Compared to the quarterly re-balancing frequency (holding period), monthly and yearly re-balanced commodity futures yield higher returns and this is true in both types of equally weighted indexes. On the other hand, at the monthly frequency, the first type of equally weighted index is offering higher returns compared to the yearly frequency but this relationship is opposite in the case of the second type of equally weighted index. This gives a clear idea that there is a survivor and exclusion bias in the Indian Commodity futures markets and rebalancing

frequencies does matter a lot. The gap between the two types of the equally weighted commodity futures indexes shows that there is a survivor and exclusion bias in the Indian commodity futures markets. Hence based on all these observations, we say the Indian commodity futures are an investible class of assets and they are the next best alternatives to the equity in India given their relative position in terms of returns performance compared to all other investible class of assets in India. Figures 2.1 to 2.6 below compare the nominal (not adjusted for inflation) and real (adjusted for inflation) returns of commodity futures with other asset classes in India during the period 2004 to 2014.

Figure 2.1: Monthly equally weighted commodity futures and commercially available commodity futures, stocks and bonds indexes nominal (not adjusted for inflation) returns from 2004 to 2014.

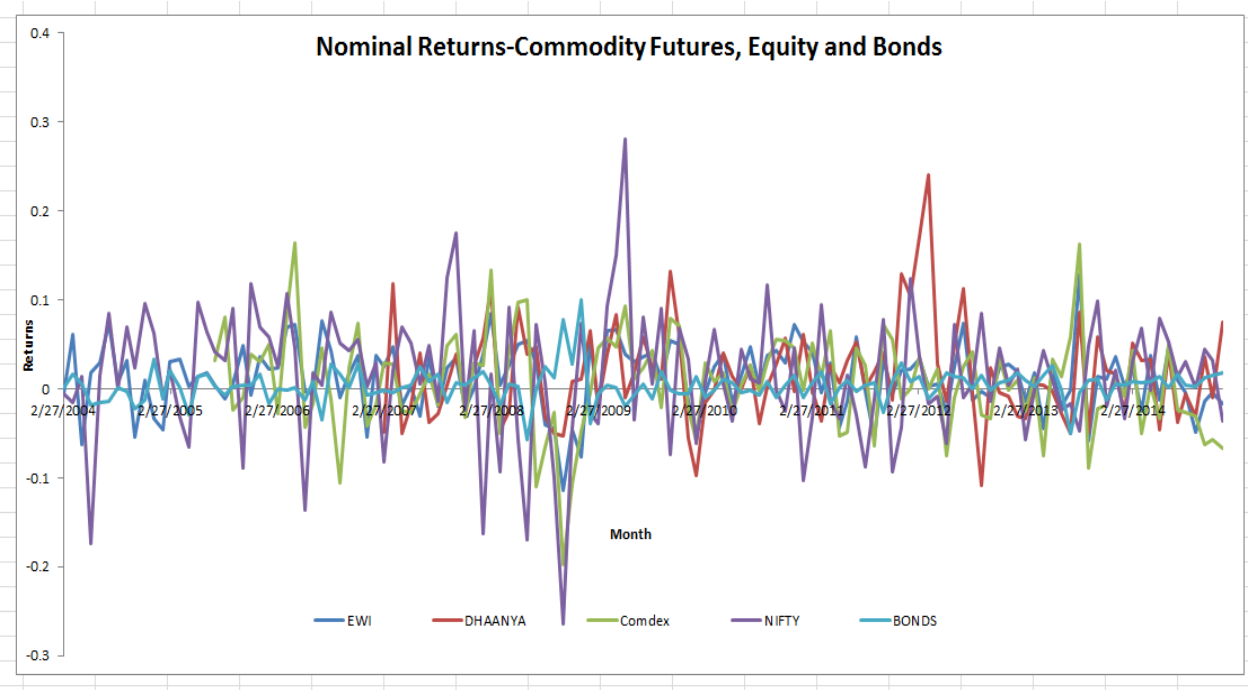


Figure 2.2: Monthly equally weighted commodity futures and commercially available commodity futures, stock and bond indexes real (adjusted for inflation) returns from 2004 to 2014.

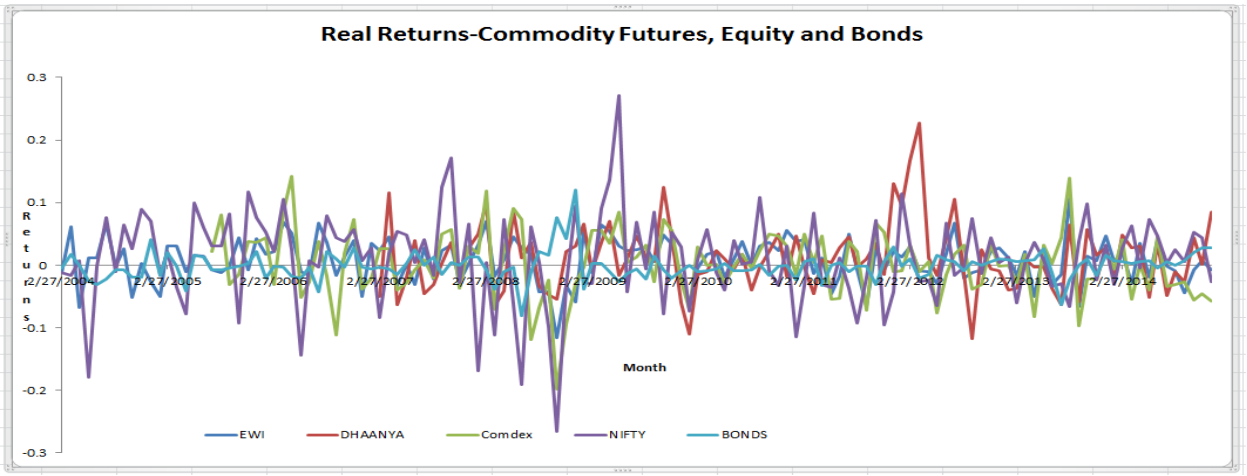


Figure 2.3: Quarterly equally weighted commodity futures and commercially available commodity futures, stocks and bonds indexes nominal (not adjusted for inflation) returns from 2004 to 2014.

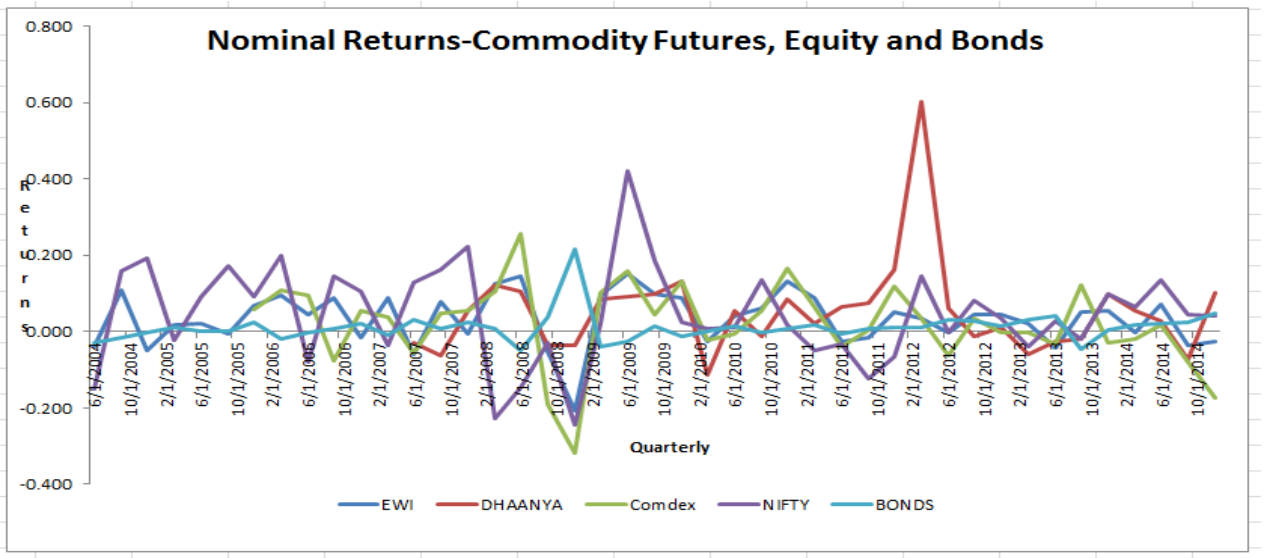


Figure 2.4: Quarterly equally weighted commodity futures and commercially available commodity futures, stock and bond indexes real (adjusted for inflation) returns from 2004 to 2014.

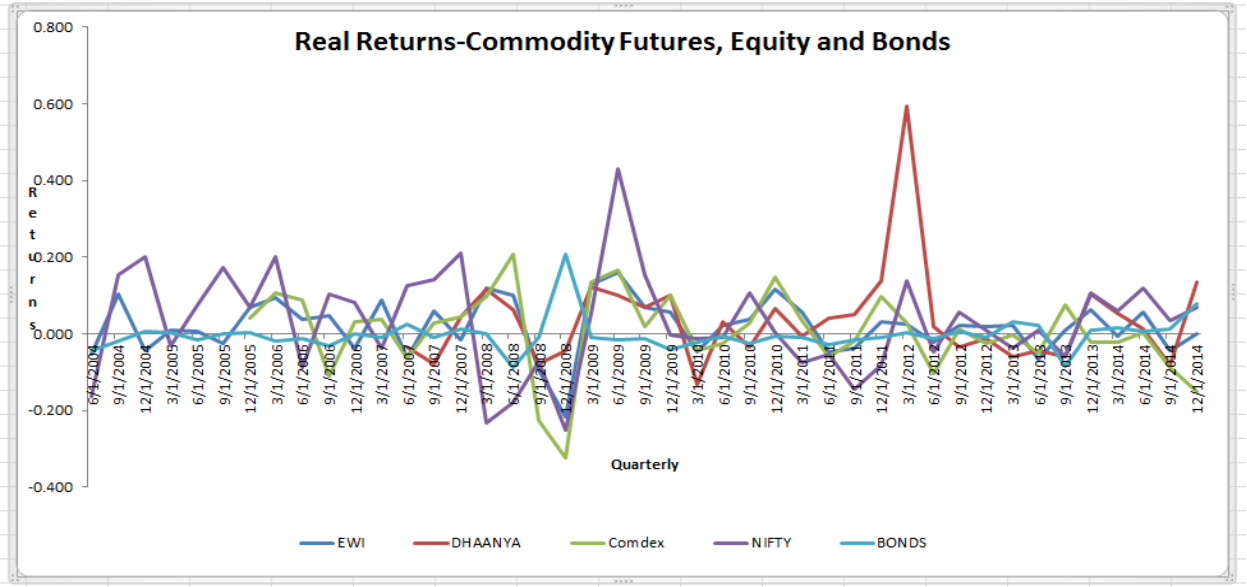


Figure 2.5: Yearly equally weighted commodity futures and commercially available commodity futures, stock and bond indexes nominal (not adjusted for inflation) returns from 2004 to 2014.

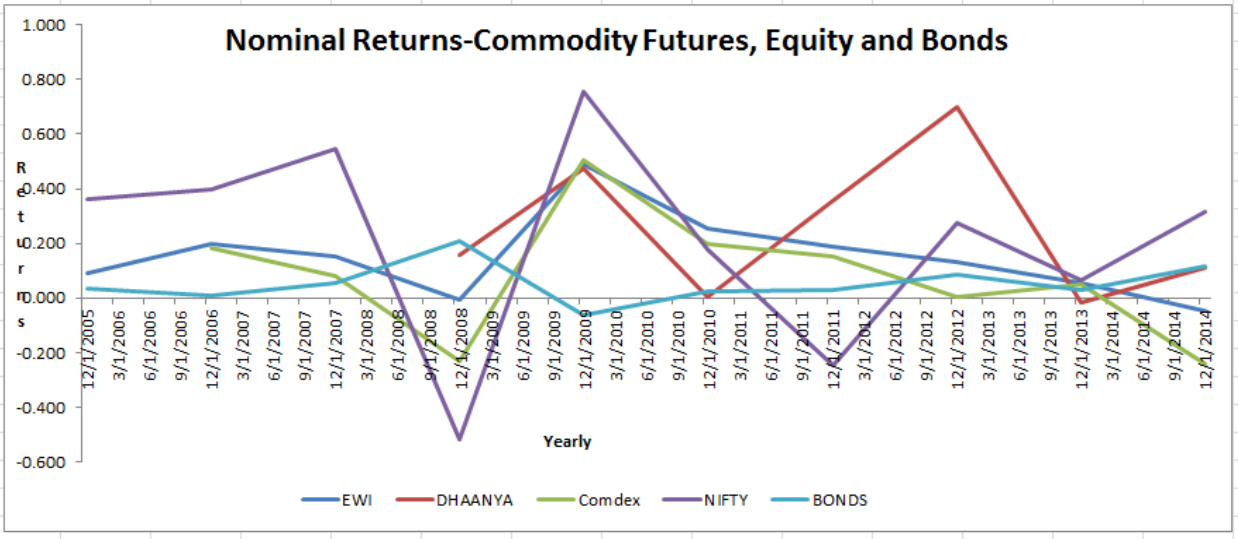
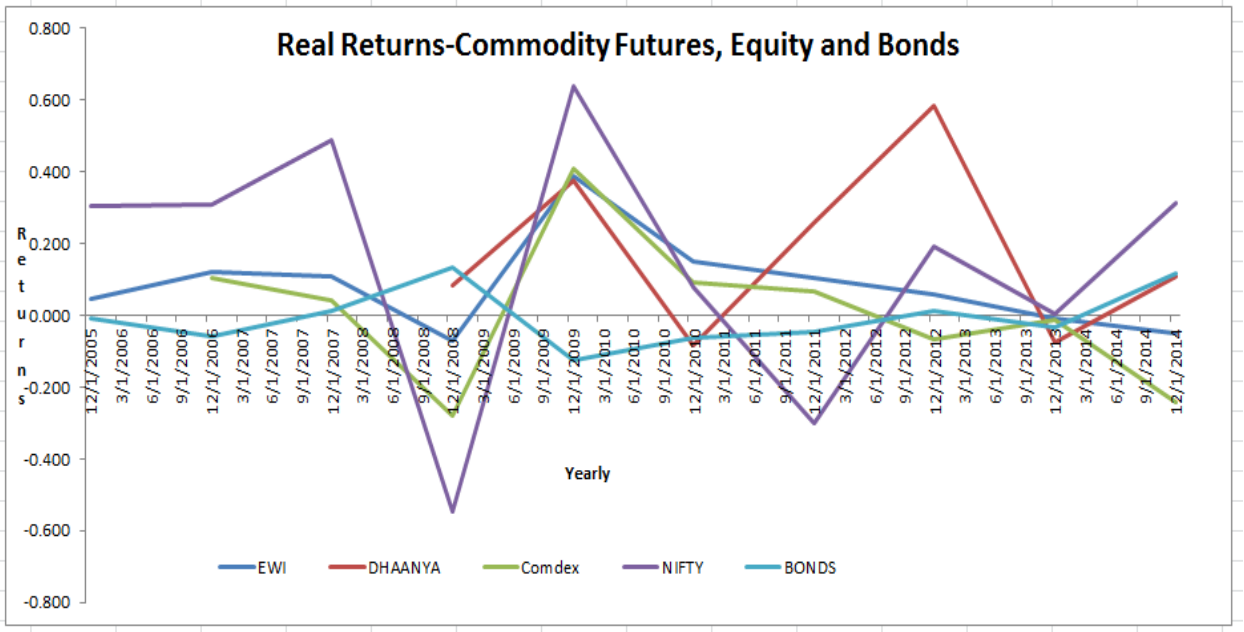


Figure 2.6: Yearly equally weighted commodity futures and commercially available commodity futures, stock and bond indexes real (adjusted for inflation) returns from 2004 to 2014.



2.4.2: The Risk and Return of Commodity Futures Compared with Equity and Bonds

Tables 2.3 and 2.4 summarize the monthly, quarterly and yearly historical risk premium for both the inflation adjusted and unadjusted returns for the three asset classes of equal weighted indexes and for the commercial indexes (commodity futures, equity and bonds). The *t*-statistic measures the confidence that the average risk premium is statistically significantly different from zero. These are just historical average returns (not annualized).

Table 2.3: Historical Risk Premium-Monthly, Quarterly and Yearly Frequency (Not Adjusted for Inflation)

Monthly	Nominal						
	EWI1	NCDEX1	MCX1	Dhaanya	Comdex	Nifty	Bonds
Average Returns	8.58	5.14	5.72	14.60	1.84	11.21	-2.00
SD	3.73	3.40	3.59	5.49	5.53	7.17	1.79
T-statistic	2.11	1.41	1.48	2.03	0.29	1.42	-1.08
Sharpe Ratio	4.02	-3.52	-2.04	11.00	-6.98	4.89	-39.49
% returns > 0	57.25	51.91	58.02	52.63	52.63	56.49	45.04
Quarterly							
Average Returns	11.43	9.19	8.61	20.19	6.21	16.42	2.28
SD	6.85	6.06	6.53	12.11	10.50	12.58	3.84
T-statistic	2.63	2.40	2.09	2.55	0.88	1.87	0.97
Sharpe Ratio	0.32	0.28	0.24	0.34	0.09	0.26	0.01
% returns > 0	62.79	67.44	60.47	64.52	56.76	65.12	60.47
Annual							
Average Returns	15.07	15.13	14.54	25.46	7.81	21.41	5.25
SD	14.40	13.04	15.67	24.57	21.54	35.32	6.88
T-statistic	0.15	0.15	0.15	0.25	0.08	0.21	0.05
Sharpe Ratio	0.85	0.95	0.75	0.92	0.23	0.53	0.36
% returns > 0	80.00	90.00	80.00	85.71	77.78	80.00	90.00

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on MCX; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform; Comdex is the MCX's composite commodity futures price index; Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market; SD stands for standard deviation; Returns are in percentages.

Table 2.4: Historical Risk Premium-Monthly, Quarterly and Yearly Frequency (Adjusted for Inflation)

Monthly	Real						
	EWI1	NCDEX1	MCX1	Dhaanya	Comdex	Nifty	Bonds
Average Returns	2.31	-0.88	-0.37	7.97	-4.12	4.94	-7.49
SD	3.52	3.28	3.39	5.46	5.31	7.20	2.18
T-statistic	0.62	-0.26	-0.10	1.14	-0.70	0.64	-3.40
Sharpe Ratio	-9.86	-18.65	-16.79	1.88	-16.73	-1.88	-54.40
% returns > 0	54.20	50.38	53.44	52.63	46.49	52.67	29.77
Quarterly							
Average Returns	5.44	13.10	2.74	13.10	-0.16	10.24	-3.33
SD	6.99	12.46	6.59	12.46	10.41	12.98	4.17
T-statistic	1.25	1.65	0.68	1.65	-0.02	1.16	-1.33
Sharpe Ratio	0.11	0.21	0.02	0.21	-0.06	0.15	-0.33
% returns > 0	62.79	58.06	53.49	58.06	54.05	55.81	25.58
Annual							
Average Returns	5.64	5.73	5.13	15.07	-1.52	11.99	-3.40
SD	12.65	11.42	13.97	22.64	19.40	33.99	7.52
T-statistic	0.06	0.06	0.05	0.08	-0.02	0.12	-0.03
Sharpe Ratio	0.23	0.26	0.17	0.54	-0.22	0.27	-0.82
% returns > 0	70.00	70.00	60.00	71.43	55.56	70.00	20.00

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on MCX; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform; Comdex is the MCX's composite commodity futures price index; Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market; SD stands for standard deviation; Returns are in percentages.

From the above tables 2.3 and 2.4 the following can be inferred:

i) The average risk premium of the combined exchanges, the equally weighted monthly, quarterly and yearly rebalanced commodity futures indexes (EWI1 (8.6 percent, 11.43 percent and 15.07 percent), NCDEX1 (5.14 percent, 8.61 percent and 14.54 percent) and MCX (5.72 percent, 8.61 percent and 14.54 percent)) are higher than Comdex (1.84 percent, 6.21 percent and 7.81 percent) and bonds (-2.00 percent, 2.28 percent and 5.25 percent) but lower than equity (11.21 percent, 16.42 percent and 21.41 percent) and Dhaanya (14.60 percent, 20.19 percent and 25.46 percent) in nominal terms. In the case of real (inflation adjusted) returns also all three equally weighted commodity futures

indexes offer higher risk premium compare to Comdex and bonds but lower risk premium compared to equity and Dhaanya.

ii) The monthly nominal risk premium of the commodity futures (EWI1, 8.58 percent) is about 4 percent lower than that of equity (11.21 percent) but four times higher than that of bonds (-2.00 percent). On the contrary, Dhaanya (14.60 percent) outperforms the equity by 3 percent and bonds by more than seven times. Similarly, the quarterly risk premium of the commodity futures is about 5 percent lower than that of equity (16.42 percent) but five times higher than that of bonds (2.28 percent) and once again, Dhaanya (20.19 percent) outperforms the equity by about 4 percent and bonds by more than nine times. Once again, similar to the monthly and quarterly risk premium analysis, the yearly re-balanced commodity futures risk premium is about 4 percent lower than equity (21.41 percent) but ten times higher than that of bonds (5.25 percent). On the contrary, Dhaanya (25.46 percent) outperforms the equity by about 4 percent and bonds by more than twenty times. However, the difference decreases by half in the case of real (inflation adjusted) returns.

iii) It is evident that as the re-balancing frequency changes from monthly to quarterly and to yearly, the average risk premium is increasing. Once again, it is true that the equally weighted commodity futures indexes are offering lower risk premium compared to equity but higher risk premium compared to bonds, which is exactly in line with annualized returns.

iv) As the re-balancing frequency changes from monthly to quarterly and then to yearly, the standard deviation of commodity futures, equity and bonds is increasing. Though in terms of the risk premium the commodity futures are lower than the equity, but equity has a higher standard deviation compared to commodity futures and bonds at all three frequencies. This indicates that equities are riskier compared to all other asset classes.

v) Once again, as the re-balancing frequency changes from monthly to quarterly and then to yearly, the Sharpe ratio of commodity futures, equity and bonds is increasing. Among these three investible asset classes, equity has a higher Sharpe ratio compared to commodity futures and bonds in all three frequencies in the case of inflation adjusted returns and monthly nominal returns. However, the equally weighted commodity futures' Sharpe ratios are the highest in the case of nominal returns at the monthly and quarterly

frequency only. These results are in contrast to the annualized returns, where in the in case of annualized returns, commodity futures yield the best risk adjusted returns among all the asset classes.

vi) The average risk premium of the combined equally weighted rebalanced commodity futures index and Dhaanya are only significant in the statistical sense (EWI1 t-statistic =2.11 and Dhaanya t-statistic = 2.03) in the monthly frequency. In the case of quarterly frequency, only EWI1 (2.63), NCDEX1 (2.40), MCX1 (2.09), Dhaanya (2.55) and equity (1.87) are statistically significant. On the other hand, neither the nominal annual frequency nor the inflation adjusted monthly, quarterly and yearly frequency indexes are statistically significant.

vii) As the rebalancing frequency changes from monthly to quarterly and then to yearly, the percentage of returns above zero is increasing in the nominal returns series as well as in the inflation adjusted return series. On an average, the commodity futures indexes are offering higher percentage returns above zero compared to equity and bonds.

From the above observations it is evident that in all three rebalancing frequencies there exists a positive risk premium in the commodity futures, which is also statistically significant. This means, commodity futures are offering more returns than the risk free rate. The commodity futures risk premium is lower (on an average 4 percent) than equity but much higher than bonds (on an average five to ten times). Though commodity futures are offering lower risk premium and risk adjusted returns (Sharpe ratios) compared to equity but they have a lower standard deviation. This means, though equity might be offering higher returns compared to commodity futures, they are too risky. On an average, commodity futures are offering positive returns most of the time compared to equity and bonds. So on the whole, once again it is clear that even in terms of the risk premium, commodity futures are the next best alternative to equity and are a good investible class of assets in India given their low levels of riskiness compared to equity.

Table 2.5 summarizes the distribution of monthly, quarterly and yearly returns on equity and commodity futures. The second row shows the historical volatility of the commodity futures and equity. The last two rows measure the asymmetry and the sharpness of the peak of the frequency distribution curve of commodity futures and equity.

Table 2.5: Monthly, Quarterly and Yearly Inflation unadjusted and adjusted Commodity Futures and Equity Distribution of Percentage Returns (simple average returns and not annualized)

Monthly	Nominal(Not Adjusted for Inflation)					
	EWI1	NCDEX1	MCX1	Dhaanya	Comdex	Nifty
Average Return	1.23	0.96	1.00	1.72	0.71	1.43
SD	3.71	3.38	3.57	5.49	5.50	7.15
Skewness	-0.28	-0.12	0.06	0.97	-0.16	-0.37
Kurtosis	0.71	1.38	2.15	2.39	1.47	2.52
Quarterly						
Average Return	3.28	2.77	2.63	5.28	2.08	4.42
SD	6.82	6.05	6.51	12.11	10.47	12.54
Skewness	-0.85	-0.49	-0.28	3.00	-0.85	0.10
Kurtosis	2.08	1.02	-0.16	13.35	2.21	1.05
Annual						
Average Return	15.07	15.13	14.54	25.46	7.81	21.41
SD	14.4	13.04	15.67	24.57	21.54	35.32
Skewness	1.07	0.97	0.89	0.75	0.28	-0.77
Kurtosis	2.06	0.95	1.07	-0.57	0.71	0.59
Monthly	Real(Adjusted for Inflation)					
Average Return	0.73	0.46	0.51	1.21	0.21	0.94
SD	3.50	3.27	3.37	5.47	5.28	7.18
Skewness	-0.35	-0.32	-0.16	0.85	-0.30	-0.42
Kurtosis	0.73	1.28	1.83	2.19	1.38	2.42
Quarterly						
Average Return	1.88	1.37	1.22	3.7	0.52	3.01
SD	6.95	6.32	6.56	12.45	10.37	12.94
Skewness	-0.64	-0.38	-0.02	2.84	-0.86	0.24
Kurtosis	1.67	0.81	0.00	12.11	1.85	1.12
Annual						
Average Return	8.42	8.51	7.91	17.88	1.30	14.77
SD	12.33	11.19	13.63	22.53	19.16	33.89
Skewness	1.38	1.11	1.15	0.63	0.40	-0.79
Kurtosis	3.06	1.82	1.37	-0.43	1.03	0.34

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on MCX; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform; Comdex is the MCX's composite commodity futures price index; Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market; SD stands for standard deviation; Returns are in percentages.

Figure 2.7: Equally weighted commodity futures and equity empirical distributions of monthly returns from 2004 to 2014.

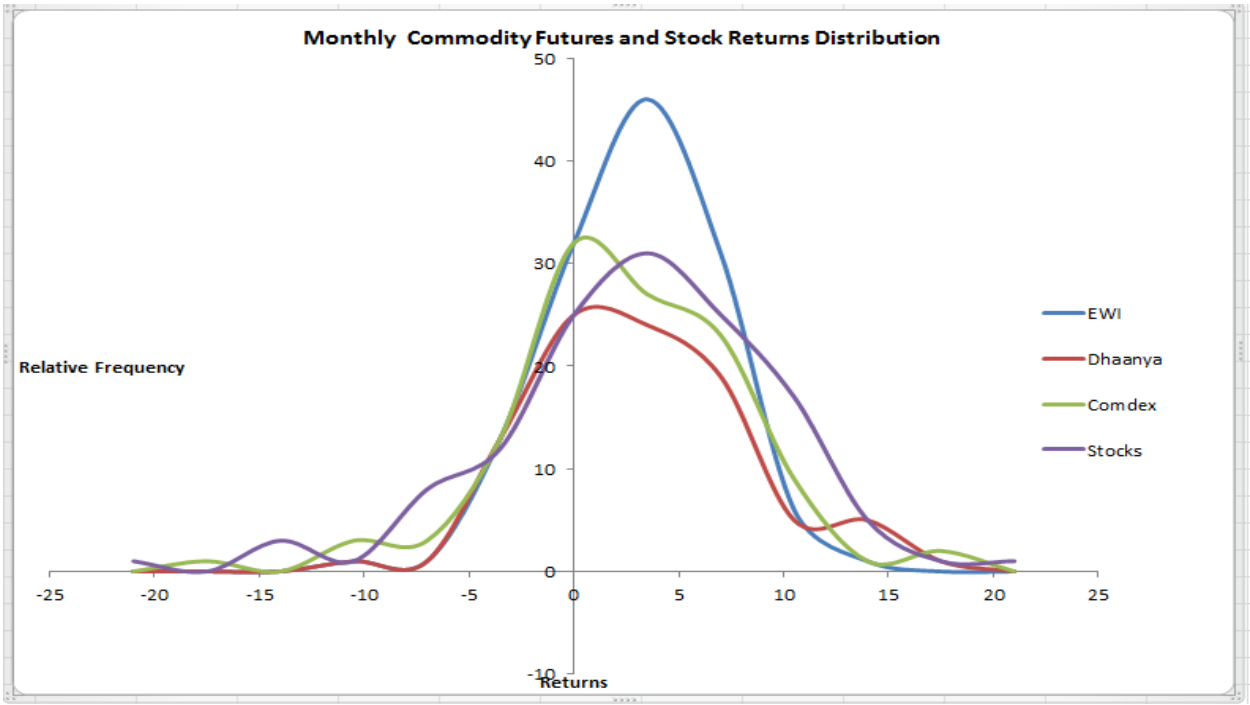


Figure 2.8: Equally weighted commodity futures and equity empirical distributions of quarterly returns from 2004 to 2014.

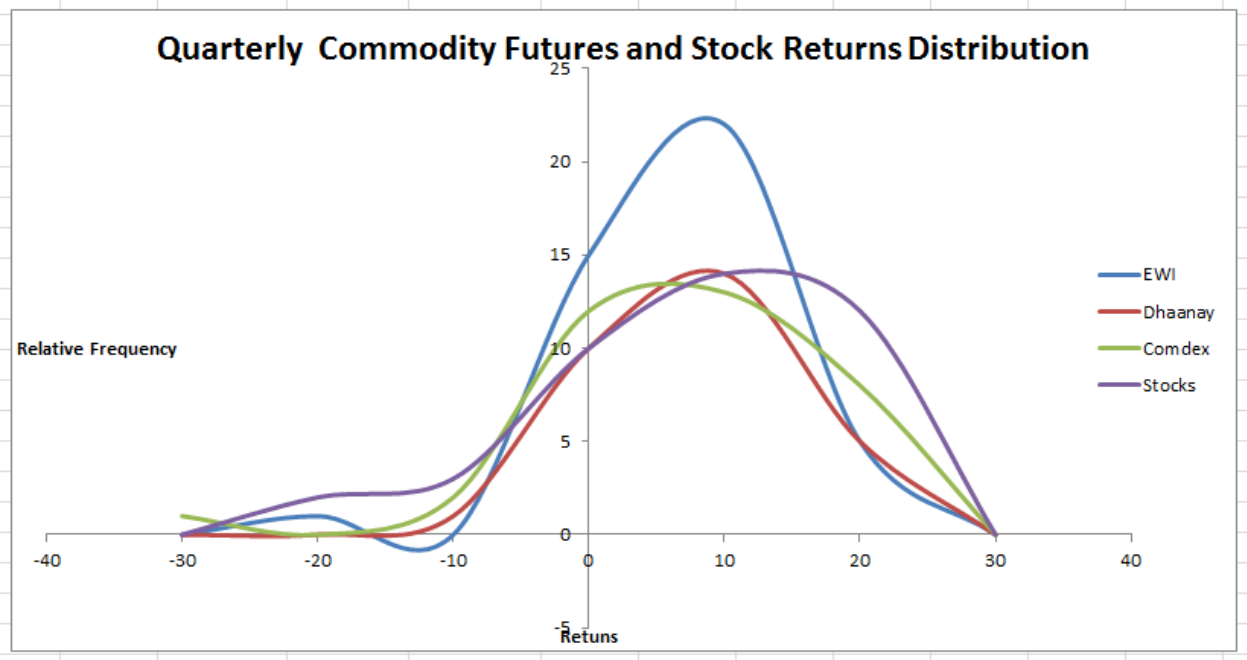
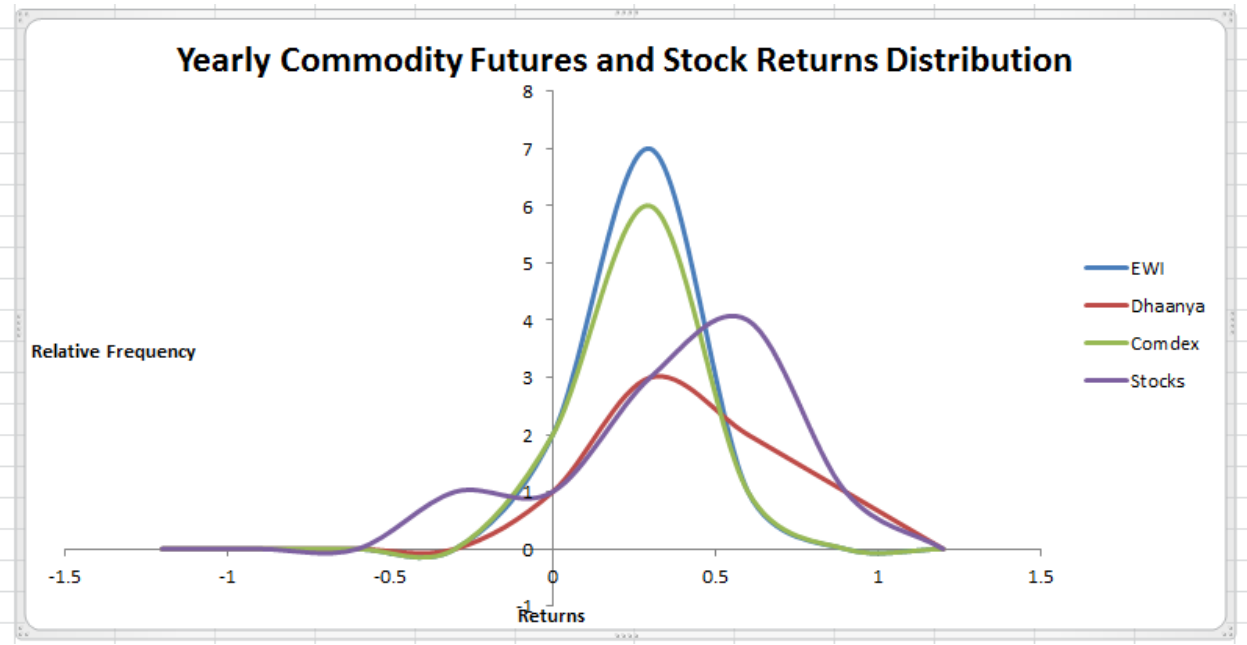


Figure 2.9: Equally weighted commodity futures and equity empirical distributions of quarterly returns from 2004 to 2014.



It is very well established in the literature that returns on financial assets often deviate from the normal distribution and display skewness and fat tails. Table 2.4 shows that this is also true for the commodities. Commodity futures returns and equity returns are negatively skewed and additionally they display relatively low kurtosis, which indicates that there are more realizations in the tails than would be expected based on the normal distribution. This analysis is further illustrated in the figures 2.7, 2.8 and 2.9. Figure 2.7 compares the empirical distribution of monthly returns for the equally weighted commodity futures index with equity and figure 2.8 compares the empirical distribution of quarterly returns for the equally weighted commodity futures index with equity. Similarly, figure 2.9 compares the empirical distribution of yearly returns for the equally weighted commodity futures index with equity. From the table 2.4 and figures 2.7, 2.8 and 2.9, we can infer the following points,

i) Monthly nominal commodity futures and equity have about the same average returns (though in terms of numbers, equity (1.43 percent) is slightly higher when compared to commodity futures ((1.23 percent) but statistically they are indifferent), but the equity (7.15 percent) standard deviation is much higher than that of the commodity futures (3.71

percent). Monthly inflation adjusted commodity futures and equity also have about the same average returns, but this time the commodity futures average returns are slightly higher than the equity though they are not different in the statistical sense. In terms of standard deviation, equity possesses double the standard deviation of the commodity futures. Exchange wise monthly equally weighted commodity futures (NCDEX1 and MCX1) indexes have lower average returns compared to equity in nominal as well as real terms. However these indexes' standard deviation is half of equity's standard deviation. Equities average returns are much higher than the commercially available commodity futures indexes (except Dhaanya) and the standard deviation is also slightly higher.

ii) The quarterly nominal commodity futures average returns (3.28 percent) are lower than that of equity (4.42 percent) average returns, but the equity (12.54 percent) standard deviation is almost double that of the commodity futures (6.82 percent). Inflation adjusted quarterly commodity futures average returns (1.88 percent) are once again lower than the equity (3.01 percent). In terms of standard deviation also, equity (12.94 percent) possesses double the standard deviation of the commodity futures (6.95 percent). Similarly, exchange wise quarterly equally weighted commodity futures (NCDEX1 and MCX1) indexes have lower average returns compared to equity in nominal as well as in real terms. However, the standard deviation of these indexes is half of the equity's standard deviation. Though equity average returns are much higher than the commercially available commodity futures index Comdex but lower than Dhaanya and the standard deviation is double of the commercial commodity futures indexes. While, Dhaanyas' average returns are higher than the equity returns, the standard deviation is more or less the same and these results are similar to the monthly frequency

iii) Yearly re-balanced nominal commodity futures average returns (15.07 percent) are lower than that of equity (21.41 percent) average returns, but the equity (35.32 percent) standard deviation is more than double that of the commodity futures (14.40 percent). Inflation adjusted yearly commodity futures average returns (8.42 percent) are once again lower than the equity (14.77 percent). In terms of standard deviation also equity (33.89 percent) possesses three times the standard deviation of the commodity futures (12.33 percent). Similarly, exchange wise yearly equally weighted commodity futures (NCDEX1 and MCX1) indexes have lower average returns compared to equity in

nominal as well as in real terms. However, the standard deviation of these indexes is half of equity's standard deviation. Though equity average returns are much higher than the commercially available commodity futures index such as Comdex but lower than Dhaanya and the standard deviation is double of the commercially available commodity futures indexes. While, Dhaanyas' average returns are higher than the equity returns, the standard deviation is half of the equity.

iv) Monthly nominal and real return distributions of equities and commodity futures have negative skewness, which means that proportionally, equities and commodity futures have more weight in the left tail of the return distribution. However, this is not always true in the case of commercially available commodity futures indexes and exchange wise indexes, where these indexes have positive skewness. This means that, proportionally equities have more weight in the left tail of the returns distribution when these are commercially available and exchange wise commodity futures have more weight in the right tail. The same is evident from figure 2.7. Monthly nominal and real return distribution of equities and commodity futures' kurtosis is less than 3; hence they possess a platykurtic distribution. This means that the probability for extreme returns is less than for a normal distribution, and the returns are widely spread around the mean.

v) The quarterly nominal and real returns distribution of commodity futures have negative skewness, while the distribution of equity and Dhaanyas' returns have positive skewness. This means that, proportionally, commodity futures have more weight in the left tail of the return distribution while equities and Dhaanya have more weight in the right tail. The same is also evident from figure 2.8. Once again similar to the monthly frequency, the quarterly nominal as well as inflation adjusted return distribution's kurtosis is less than 3, hence they are platykurtic. This means that the probability for extreme returns is less than for a normal distribution and the returns are widely spread around the mean. On the other hand, only Dhaanyas' kurtosis is higher than 3, hence Dhaanya index returns distribution is leptokurtic and which means that the returns are concentrated around the mean and are fat tailed relative to the normal distribution.

vi) Contrary to the monthly and quarterly returns distribution, the yearly nominal and real returns distribution of commodity futures have positive skewness, while the distribution of equity has negative skewness. This means that proportionally commodity futures have

more weight in the right tail of the return distribution while equity has more weight in the left tail. The same is also evident from figure 2.9. The yearly nominal and real return distribution of equities and commodity futures' kurtosis is less than 3 except the equally weighted commodity futures index, namely EWI1, whose kurtosis is slightly higher than 3. Other than EWI1 index, rest of the indexes possesses platykurtic distribution. This means that the probability for extreme returns is less than for a normal distribution, and the returns are widely spread around the mean. Since the EWI1' kurtosis is more than 3, it possesses leptokurtic distribution and this means that the returns are concentrated around the mean and are fat tailed relative to the normal distribution.

From above observations it is evident that monthly nominal and real commodity futures and equity have about the same average returns but equity has the higher standard deviation. Similarly, exchange wise indexes such as the NCDEX1 and MCX1 have lower average returns compared to equities but once again the equities standard deviation is double of these indexes. It is also true in the case of commercially available commodity futures indexes, where these indexes averages and standard deviations are lower than equity. On an average, monthly nominal and real returns distribution of equities and commodity futures have negative skewness, which means that proportionally, equities and commodity futures have more weight in the left tail of the return distribution. Similarly, the monthly nominal and real return distribution of equities and commodity futures' kurtosis is less than 3, hence they possess platykurtic distribution. This means that the probability for extreme returns is less than for a normal distribution, and the returns are widely spread around the mean.

At the quarterly frequency, all the commodity futures (except Dhaanya) indexes average returns are lower but the equity's standard deviation is almost double. Whereas, Dhaanya index average returns are higher than the equity returns, the standard deviations are more or less the same. In terms of skewness, the nominal and real commodity futures are similar to the monthly frequency but the equity is in the opposite direction and it possesses positive skewness. In terms of kurtosis, once again, it is similar to the monthly frequency where it less than 3 (except Dhaanya index, whose kurtosis is more than 3), which means that the probability for extreme returns is less than a normal distribution, and the returns are widely spread around the mean. On the other hand, the

Dhaanyas' kurtosis is higher than 3, hence its returns distribution is leptokurtic. The returns are concentrated around the mean and are fat tailed relative to the normal distribution.

Similar to the monthly and quarterly return frequencies, yearly re-balanced all the commodity futures (except Dhaanya) indexes average returns are lower than the equity and their standard deviation is half of the equity. Whereas, the Dhaanya index average returns are higher than the equity returns but their (i.e. Dhaanyas' and equity's) standard deviations are more or less the same. However, in terms of skewness and kurtosis the yearly returns distribution is exactly opposite to the monthly and quarterly returns distribution. Yearly re-balanced nominal and real returns distribution of commodity futures have positive skewness, while the distribution of equity has negative skewness. This means that proportionally commodity futures have more weight in the right tail of the return distribution while equity has more weight in the left tail. Similarly, yearly nominal and inflation adjusted equities and commodity futures' kurtosis is less than 3 except EWI1, whose kurtosis is slightly higher than 3. Other than EWI1 index, rest of the indexes possesses platykurtic distribution. This means that the probability for extreme returns is less than for a normal distribution, and the returns are widely spread around the mean. Since the EWI1s' kurtosis is more than 3, it possesses leptokurtic distribution and this means that the returns are concentrated around the mean and are fat tailed relative to the normal distribution.

So, on the whole it is evident that except Dhaanya index, all the nominal and inflation adjusted commodity futures indexes returns and their standard deviations are lower than the equity. This is true in all three re-balancing frequencies. Though Dhaanya index is relatively less risky but offering higher returns compare to equity in all three holding periods. In terms of skewness the commodity futures returns are negatively distributed at the monthly and quarterly frequency whereas at the yearly frequency the direction is opposite (i.e. changed into a positive direction). On the other hand, equity returns are negatively distributed in the case of monthly and yearly frequencies but positively distributed at the quarterly frequency. This indicates that in the case of positive skewness, returns have more weight in the right tails whereas, in the case of negative skewness, returns have more weight in the left tails. Similarly, on an average, all the assets class indexes kurtosis is less than 3 (except quarterly Dhaanya index and yearly EWI1). This indicates that the probability for extreme returns is less than for a normal distribution, and the returns are widely spread around the mean.

2.4.3: The Correlation of Commodity Futures with Other Asset Classes

In this section we examine the correlation of commodity futures returns with those of equity, bonds and inflation over monthly, quarterly and yearly horizons. Table 2.6 illustrates the correlation of monthly, quarterly and yearly equally weighed and commercially available commodity futures indexes with equity, bonds and inflation during the period January 2004 to December 2014.

Table 2.6: Correlation between Commodity Futures, Stocks, Bonds, and Inflation

Index/Frequency	Nominal			Real		
Monthly	Nifty	Bonds	Inflation	Nifty	Bonds	Inflation
EWI1	0.18*	-0.35*	0.36*	0.19*	-0.30*	0.18*
NCDEX1	0.10	-0.29*	0.24*	0.12	-0.18*	0.02
MCX1	0.14	-0.29*	0.34*	0.14	-0.23*	0.16*
Dhaanya	0.03	-0.10	0.05	0.04	-0.01	-0.09
Comdex	0.21*	-0.44*	0.32*	0.20*	-0.39*	0.20*
Quarterly						
EWI1	0.27*	-0.68*	0.01	0.33*	-0.51*	-0.22
NCDEX1	0.14	-0.56*	-0.07	0.22	-0.35*	-0.32*
MCX1	0.21	-0.56*	0.09	0.27*	-0.44*	-0.15
Dhaanya	0.11	-0.19	-0.18	0.19	-0.03	-0.32*
Comdex	0.18	-0.78*	0.04	0.23	-0.65*	-0.13
Annual						
EWI1	0.53	-0.81*	0.56	0.58	-0.83*	0.42
NCDEX1	0.46	-0.76*	0.50	0.51	-0.76*	0.33
MCX1	0.58	-0.80*	0.53	0.62	-0.82*	0.40
Dhaanya	0.31	-0.17	0.18	0.33	-0.13	0.06
Comdex	0.57	-0.93*	0.54	0.57	-0.95*	0.47

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on MCX; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform; Comdex is the MCX's composite commodity futures price index; Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market."*" next to a coefficient indicates that the correlation is significant at the 5% level.

From table 2.6 the following can be inferred,

i) All the equally weighted monthly, quarterly and yearly re-balanced commodity futures indexes are positively correlated with equity in nominal and real terms. However, only the EWI1 index is statistically significant in the case of monthly and quarterly frequency irrespective of the inflation adjustment and Comdex is statistically significant in the case of the monthly frequency only.
ii) As the re-balancing frequency changes from the monthly to quarterly and to yearly, the correlation between the commodity futures and equity becomes stronger but not statistically significant. This is true in nominal terms as well as in real terms.
iii) All the commodity futures indexes are negatively correlated with the bonds irrespective of the re-balancing frequency and inflation adjustment. The correlation between commodity futures and bonds is statistically significant except in the case of Dhaanya index.
iv) Monthly re-balanced nominal commodity futures indexes are positively correlated with inflation and this correlation is also statistically significant except in the case of the Dhaanya index. Once again except Dhaanya, monthly re-balanced inflation adjusted commodity futures are also positively correlated. However, Dhaanya is negatively correlated but it is not statistically significant.
v) Quarterly re-balanced EWI1, MCX1 and Comdex are positively correlated with inflation but not statistically significant. On the other hand, NCDEX1 and Dhaanya are negatively correlated with inflation but not statistically significant. On the contrary, all the equally weighted quarterly re-balanced inflation adjusted commodity futures indexes are negatively correlated and this negative correlation is statistically significant (except MCX1 index).
vi) Contrary to the monthly and quarterly frequency, the yearly re-balanced commodity futures indexes are positively correlated with inflation but not statistically significant. Statistically insignificant positive correlation between all the commodity futures indexes and inflation exists in the case of the inflation adjusted returns series also. These positive coefficients are higher in the case of the yearly re-balanced frequency compared to the monthly re-balanced frequency.

From the above observations it is evident that commodity futures returns are positively correlated with equity returns. The positive correlation between commodity futures and equity becomes stronger as we change the re-balancing frequency from monthly to quarterly and then to yearly. However, this stronger positive correlation between commodity futures and equity is statistically significant neither in nominal nor in real terms. Contrary to equity, monthly, quarterly and yearly re-balanced all the commodity futures indexes are negatively correlated with the bonds in nominal as well as in real terms. The negative correlation between commodity futures and bonds is also statistically significant and it becomes weaker as the re-balancing frequency changes from monthly to quarterly and then to yearly. The negative correlation between commodity futures and bonds leads to better portfolio diversification. At times when either one of the asset classes is generating negative returns, simultaneously the other asset class provides positive returns, hence on an average, the investor will be safe. The correlation between commodity futures and inflation is not in one direction. Monthly commodity futures are positively correlated with inflation, whereas the quarterly commodity futures are negatively correlated with inflation. On the contrary, yearly re-balanced commodity futures are positively correlated with inflation. Compared to the monthly positive correlation between commodity futures and inflation, the yearly positive correlation is stronger but not in the statistical sense. This stronger correlation better captures the inflation properties of a commodity futures investment.

2.4.4: Correlation of Assets with Inflation

In this section, we examine the relationship between the asset classes and inflation over the monthly, quarterly and yearly time horizons. The real purchasing power of the returns of their asset class matters a lot for investors, which means investors worry about the inflation threat. In the literature it has been proven that at least in the short to medium time horizons most of the traditional asset classes are a poor hedge against inflation (Gorton and Rouwenhorst, 2006). According to their maturity period, bond yields are set to compensate investors for expected inflation. The real purchasing power of returns will fall short of the expectations of investors if there is higher unexpected inflation, and investors will revise their future expected inflation accordingly to minimize the loss. Economics and finance theory expect that equities provide a

better hedge than bonds; however determining to what extent equities provide a hedge against inflation is an empirical matter.

From table 2.6 it is evident that commodity futures, bonds and equities are sensitive to unexpected inflation. In order to capture the impact of unexpected inflation on these asset classes, we need to measure unexpected inflation, for this we need a model of expected inflation. The previous studies (e.g. Fama and Schwert (1977), Schwert (1981) and Gorton and Rouwenhorst (2006)) use a simple method to achieve this and we also follow the same method in this study. If the expected real rate of interest is constant over time, then we can assume that the three month Treasury bill yield is a proxy for the market's expectation of inflation. Consequently, unexpected inflation can be measured as the actual inflation rate minus the nominal interest rate (which was known ex ante).

Since inflation is persistent over time, market participants revise their estimates of future expected inflation from time to time due to unexpected inflation shocks. By following the literature[6], the change in the nominal interest rate has been considered as the change in expected inflation. The change in inflation is not necessarily perfectly correlated with the unexpected inflation rate because investors may use more information than just the current rate of inflation to revise their expectations of future inflation from time to time (Gorton and Rouwenhorst (2006).

Table 2.7 summarizes correlations between monthly, quarterly and yearly nominal and real equally weighted re-balanced commodity futures indexes (EWI1, NCDEX1, MCX1) and inflation and its components such as changes in expected inflation and unexpected inflation. To obtain more clarity we also report the correlation between commercially available commodity futures indexes (NCDEX's Dhaanya, MCX's Comdex), equities and bonds with inflation and its components for the period from January 2004 to December 2014. Change in inflation is the difference between current period inflation and the previous period's inflation. Whereas, the unexpected is the difference between the inflation rate and the three month Treasury bill yield.

[6]See Fama and Schwert (1977), Schwert (1981) and Gorton and Rouwenhorst (2006) for a discussion on the subject.

Table 2.7: Correlation between Asset returns and Components of Inflation

Index/Frequency	Nominal			Real		
Monthly	Inflation	Change in Inflation	Unexpected Inflation	Inflation	Change in Inflation	Unexpected Inflation
EWI1	0.36*	0.18*	0.37*	0.18*	0.12	0.20*
NCDEX1	0.23*	0.23*	0.24*	0.02	0.17*	0.03
MCX1	0.34*	0.18*	0.36*	0.16*	0.12	0.18*
Dhaanya	0.05	0.18*	0.04	-0.09	0.13	-0.10
Comdex	0.32*	0.16	0.35*	0.19*	0.12	0.23*
Nifty	-0.06	0.09	-0.03	-0.15*	0.05	-0.12
Bonds	-0.43*	-0.07	-0.45*	-0.67*	-0.17*	-0.68*
Quarterly						
EWI1	0.01	0.03	0.04	-0.22	-0.11	-0.19
NCDEX1	-0.07	0.00	-0.06	-0.32*	-0.15	-0.30*
MCX1	0.09	0.11	0.11	-0.15	-0.04	-0.13
Dhaanya	-0.18	-0.10	-0.18	-0.32*	-0.19	-0.33*
Comdex	0.04	0.13	0.06	-0.13	0.03	-0.11
Nifty	-0.22	0.13	-0.22	-0.35*	0.05	-0.35*
Bonds	-0.02	-0.32*	-0.03	-0.41*	-0.51*	-0.42*
Annual						
EWI1	0.56	0.38	0.63	0.42	0.26	0.50
NCDEX1	0.50	0.21	0.55	0.33	0.05	0.39
MCX1	0.53	0.50	0.61	0.40	0.41	0.50
Dhaanya	0.18	0.01	0.20	0.06	-0.09	0.08
Comdex	0.54	0.34	0.59	0.47	0.27	0.51
Nifty	-0.24	-0.23	-0.18	-0.32	-0.30	-0.26
Bonds	-0.31	-0.09	-0.31	-0.59	-0.34	-0.58

Note: EWI1 Stands for Equally Weighted Index and it is constructed on the basis that commodities futures contracts should be traded on either of the exchanges; NCDEX1 stands for National Commodity & Derivatives Exchange Limited, which includes all the commodity futures contracts that are traded on NCDEX; MCX1 stands for Multi Commodity Exchange of India Ltd, which includes all the commodity futures contracts that are traded on the MCX; Dhaanya is the NCDEX's value weighted index, computed in real time using the prices of the 10 most liquid commodity futures traded on the NCDEX platform ;Comdex is the MCX's composite commodity futures price index; Nifty is the National Stock Exchange of India's benchmark stock market index for the Indian equity market; Inflation percentage change in the Whole sale price index (2010 is the base year). Bond returns are calculated from NSE Bond total return index; Change in Inflation is calculated as the difference between current period inflation and the previous period inflation; Unexpected Inflation is calculated as the difference between inflation and the 3 month Treasury bill yield."*" next to a coefficient indicates that the correlation is significant at the 5% level of significance.

From table 2.7, we can infer the following points,

i) The positive sensitivities of monthly nominal returns on commodity futures to inflation stem mainly from sensitivity to unexpected inflation. The positive correlations with unexpected inflation exceed the raw inflation correlations. Nominal returns on bonds and equities are negatively sensitive to unexpected inflation but the equities coefficient is not statistically significant. The sensitivity to inflation is in the opposite direction compared to the commodity futures. Nominal returns on bonds are negatively influenced by revisions about future expected inflation. Revisions about future inflationary expectations have a positive influence on commodity futures as well as on equities.

ii) Monthly real returns on commodity futures are positively sensitive to unexpected inflation. On the other hand, the commercially available Dhaanya index is negatively correlated with unexpected inflation. Once again, similar to the monthly nominal frequency, in the real returns frequency also the positive correlations with unexpected inflation exceed the raw inflation correlations. Real returns on bonds and equities are negatively sensitive to unexpected inflation. Real returns on bonds are negatively influenced by revisions about future expected inflation. A revision of future inflationary expectations has a positive influence on the commodity futures as well as on equities and it is similar to the nominal frequency.

iii) The positive sensitivities of quarterly nominal returns on commodity futures to inflation stem mainly from sensitivity to unexpected inflation (but none of the coefficients are statistically significant). The positive correlations with unexpected inflation exceed the raw inflation correlations, and this is similar to the monthly frequency. Contrary to the monthly frequency, the Dhaanya index is negatively sensitive to unexpected inflation.

iv) Nominal returns on bonds and equities are negatively sensitive to unexpected inflation, but both the equities and bonds coefficients are not statistically significant. The sensitivity to inflation is in the opposite direction when compared to commodity futures. Nominal returns on bonds and equities are negatively influenced by revisions of future expected inflation. Revisions of future inflationary expectations have a positive influence on commodity futures. Contrary to the monthly and quarterly nominal returns frequency, the quarterly real returns on commodity futures, both the equally weighted indexes and commercially available indexes are negatively sensitive to unexpected inflation. Real

returns on bonds and equities are negatively sensitive to unexpected inflation. The negative correlations with unexpected inflation exceed raw inflation. Real returns on commodity futures, equities and bonds are negatively influenced by revisions of future expected inflation. Revisions about future inflationary expectations have a negative influence on commodity futures as well as on equities and bonds.

v) None of these yearly coefficients (includes nominal as well as inflation adjusted) are statistically significant. So, all these inferences are based on the direction and magnitude only and not in the statistical sense. Similar to the monthly nominal and real frequency, the positive sensitivities of yearly nominal commodity futures returns to inflation stem mainly from sensitivity to unexpected inflation. The positive correlations with unexpected inflation exceed the raw inflation correlations. Nominal returns on bonds and equities are negatively sensitive to unexpected inflation. The sensitivity to inflation is in the opposite direction compared to commodity futures. Nominal returns on bonds and equities are negatively influenced by revisions about future expected inflation. Revisions about future inflationary expectations have a positive influence on commodity futures but negative influence on equities and bonds.

From the above observations it is evident that commodity futures are positively sensitive to unexpected inflation. The positive correlations with unexpected inflation exceed the raw inflation correlations. As the holding period changes from the monthly to quarterly and then to the yearly frequency, commodity futures' sensitivity to inflation switches from the positive to negative regime and then falls back to the positive regime. However, equities and bonds continue to be negatively sensitive to changes to inflation and unexpected inflation irrespective of the holding period. Revisions about future inflationary expectations have a positive influence on commodity futures but negative influence on equities and bonds. On the whole, commodity futures have an opposite exposure at the monthly and yearly frequency, but the same exposure in the case of the quarterly frequency. Since inflation is persistent over time, unexpected inflation often causes market participants to revise their estimates of future expected inflation in order to maintain the purchasing power of their returns. So the above analysis indicates that commodity futures are the better hedge against inflation given the changes in the inflation components and their positive relationship with commodity futures returns.

2.4.5: Commodity Futures Performance: Commodity-wise Analysis

In the earlier sections, it is proved that the equally weighted commodity futures index is out performed the bonds, Treasury bills and inflation but underperformed the equity. Similarly, it is also proved that there exists a positive risk premium and the commodity futures can also be hedged against inflation and to its components such as expected and unexpected inflation. Whereas in terms of risk which is measured by the standard deviation reveals that though commodity futures are less volatile compare to equity but higher than the bonds. Since all these performance measures are at the aggregated index level, then the next obvious question could be will there be a similar performance at the commodity level. In order to answer the broader question in a detailed manner, we further split the broader question into four sub questions and they are as follows:

i) Which all are the commodity futures are performing similar to equally weighted index in terms of returns compare to equity, bonds, Treasury bills and inflation?

ii) Do all the commodity futures exhibit the same risk return relationship?

iii) Which all the commodity futures are hedgeable against inflation and its components?

iv) Is the volatility uniform across the commodity futures?

We perform a detailed analysis using more robust techniques. The employed techniques are time series in nature; hence we select the commodity futures which have traded at least thirty (30) months consecutively. The first question is analyzed in the next section and the other questions are analyzed in the subsequent chapters in a detailed manner.

2.4.6: Commodity wise Monthly, Quarterly and Yearly Returns

In order to answer the question as "which all are the commodity futures are performing similar to equally weighted index in terms of returns compare to equity, bonds, Treasury bills and inflation?", we calculate both exchanges (MCX and NCDEX) commodity wise monthly, quarterly and yearly holding period nominal as well as real returns during the sample period from January 2004 to December 2014.

Table 2.8: Monthly, Quarterly and Yearly Average Annualized Commodity Futures Nominal and Real Returns 2004 to 2014-MCX Exchange

Commodity-MCX	Sector	Nominal			Real		
		M	Q	Y	M	Q	Y
Almond	Agri	8.99	13.82	8.97	-0.12	4.34	0.81
Aluminium	NP	1.20	0.30	3.06	-3.84	-5.59	-1.55
Aluminium Mini	NP	5.19	2.42	0.82	-0.96	-3.97	-5.29
Areca Nut (Jhaji)	Agri	-4.98	-2.14	7.29	-10.17	-7.76	1.94
ATF	Ener	6.35	12.77	28.11	-0.20	6.20	20.00
Brent Crude	Ener	21.21	20.61	19.34	14.66	11.31	13.38
Cardamom	Agri	27.91	35.89	26.19	20.51	27.98	20.08
CER	Envi	-23.11	-21.99	-12.52	-27.95	-27.83	-20.82
Chana	Agri	19.07	28.36	5.10	12.31	24.36	-0.39
Chana-Delhi	Agri	27.29	18.41	17.69	17.55	11.39	9.57
Copper	NP	15.49	17.55	15.19	9.01	9.72	8.99
Copper Mini	NP	0.62	0.39	0.03	-3.80	-4.76	-4.58
Coriander	Agri	-9.37	-8.33	-5.84	-14.98	-14.79	-13.95
Cotton	Agri	-2.07	-0.54	-0.77	-6.23	-5.66	-5.38
CPO	Agri	1.64	25.29	12.74	-3.67	17.78	6.38
Crude oil	Ener	9.50	11.89	9.79	3.26	3.48	3.59
Flake Menthol	Agri	52.28	70.47	17.96	40.64	56.84	10.22
Gasoline	Ener	22.91	36.87	21.29	12.79	26.16	12.69
Gold	Prec	16.26	17.45	15.75	9.69	10.05	9.55
Gold Guinea	Prec	14.23	12.95	13.38	7.97	6.15	7.03
Gold Mini	Prec	16.33	17.41	15.93	9.76	10.00	9.73
Gold Petal	Prec	5.50	6.79	-0.69	0.77	0.86	-5.29
Gold Petal (Delhi)	Prec	-1.17	0.43	-0.26	-5.39	-4.73	-4.87
Guar Seed	Agri	58.67	20.48	32.71	49.05	13.25	25.80
Heating oil	Ener	29.05	35.64	31.36	18.92	25.99	22.76

Note: M= Monthly Q=quarterly; Y =yearly; agri=agriculture; Ener=energy; NP=non-precious metals; Prec=precious metals; Envi=environmental products; Returns are in percentages.

Table 2.9: Monthly, Quarterly and Yearly Average Annualized Commodity Futures Nominal and Real Returns 2004 to 2014 -MCX Exchange (contd…)

Commodity-MCX	Sector	Nominal			Real		
		M	Q	Y	M	Q	Y
Kapas	Agri	18.75	17.44	9.70	11.60	10.78	3.50
Kapaskhali	Agri	14.80	26.88	26.24	8.50	19.08	20.04
Lead	NP	8.77	1.42	12.24	2.43	-4.88	5.83
Lead Mini	NP	11.24	10.61	1.29	5.19	3.70	-4.10
Maize	Agri	18.31	25.07	20.29	9.18	16.34	13.33
Menthaoil	Agri	18.79	21.16	4.84	12.13	15.97	-1.36
Natural Gas	Ener	2.07	4.90	-2.60	-3.68	-1.41	-8.70
Nickel	NP	6.12	11.50	14.50	0.19	5.74	8.30
Nickel Mini	NP	1.10	0.50	-0.58	-3.35	-4.66	-5.19
Pepper	Agri	16.38	23.58	17.94	10.82	18.69	12.06
Platinum	Prec	-16.65	-13.87	20.68	-21.72	-20.22	12.57
Refined Soyoil	Agri	7.73	9.37	12.39	0.75	3.51	5.35
Rubber	Agri	22.84	25.44	24.06	14.24	19.22	17.07
Silver	Prec	17.66	16.96	15.67	11.02	9.81	9.47
Silver Mini	Prec	17.81	16.77	15.70	11.17	9.64	9.50
Silver Micro	Prec	-3.03	-8.71	-9.57	-7.87	-14.20	-14.18
Soyabean	Agri	15.02	21.64	10.71	5.45	12.05	2.60
Sugar Mini (Kolkata)	Agri	2.78	6.41	14.46	-4.67	-2.90	7.15
Thermal Coal	Ener	14.83	19.94	21.02	5.54	9.34	12.42
Tin	NP	19.15	33.07	17.93	10.86	24.59	10.18
Turmeric	Agri	83.09	73.70	67.50	72.06	64.26	60.59
Urad	Agri	54.86	58.45	11.23	47.26	57.69	4.27
Wheat	Agri	17.29	21.53	12.60	7.90	12.85	4.49
Zinc	NP	4.80	4.44	3.95	-1.41	-2.04	-2.16
Zinc Mini	NP	12.42	13.12	6.31	6.30	6.09	0.92

Note: M= Monthly Q=quarterly; Y =yearly; agri=agriculture; Ener=energy; NP=non-precious metals; Prec=precious metals; Envi=environmental products; Returns are in percentages.

Table 2.10: Monthly, Quarterly and Yearly Average Annualized Commodity Futures Nominal and Real Returns 2004 to 2014 -NCDEX Exchange

Commodity-NCDEX	Sector	Nominal			Real		
		M	Q	Y	M	Q	Y
Barley	Agri	12.99	13.78	8.77	6.52	7.13	2.66
Brent Crude Oil	Ener	9.69	17.84	0.03	3.31	10.36	-5.67
Castor (Disa)	Agri	8.55	17.94	16.30	3.13	12.23	10.95
Castor Seed	Agri	17.06	15.33	13.16	9.85	7.54	6.96
Chana	Agri	9.16	11.29	6.00	3.07	5.21	-0.10
Chilli LCA 334	Agri	21.79	13.47	9.65	13.85	5.39	2.59
Cotton Seed Oilcake	Agri	11.38	8.32	3.96	4.64	1.06	-2.24
Cotton Seed Oilcake (Akola)	Agri	29.22	18.41	19.78	22.23	12.25	14.43
Cotton Seed Oilcake (Kadi)	Agri	17.97	18.16	27.85	10.54	9.49	23.84
Copper before 2010	NP	12.10	18.06	-26.71	5.75	12.98	-32.06
Copper since 2010	NP	8.04	8.42	4.20	1.59	1.16	-2.00
Medium Staple Cotton	Agri	14.64	10.62	12.23	8.24	4.77	6.88
Crude Oil	Ener	6.85	10.81	7.15	0.62	3.97	0.74
Dhaniya	Agri	14.45	16.21	20.73	8.59	9.80	14.37
Furnace oil	Ener	18.78	24.65	9.26	12.24	18.25	3.92
Guar Gum	Agri	57.71	41.70	64.59	48.44	32.78	57.58
Gold Pure Kg (Mumbai)	Prec	28.28	19.84	21.75	22.09	11.48	16.40
Groundnut Expeller Oil	Agri	14.12	12.94	3.36	7.42	7.00	-1.99
Groundnut(in shell)	Agri	15.07	15.04	5.37	8.32	9.02	0.02
Gold	Prec	8.38	7.71	7.75	2.60	1.22	2.36
Gold 100 Grams	Prec	24.27	24.25	27.77	14.84	14.31	19.18
Gur	Agri	17.63	17.13	16.87	10.71	9.90	10.46
Gur (MZFNR)	Agri	17.63	17.13	16.87	10.71	9.90	10.46
Jeera	Agri	11.72	19.04	8.47	5.36	11.88	2.36
Jute Sacking	Agri	15.68	-6.21	10.83	8.65	-14.92	9.81
Raw Jute	Agri	23.49	19.40	15.16	16.85	13.93	9.81
V 797 Kapas	Agri	14.21	15.57	10.89	7.85	8.77	4.78
Yellow/Red Maize	Agri	16.15	18.57	7.72	9.41	11.59	1.78
RMseed oilcake	Agri	30.34	23.99	29.61	22.77	17.62	24.26
Masoor Bold	Agri	26.98	32.31	51.85	20.03	25.62	46.51
Nickel	NP	1.73	6.57	17.96	-5.65	-1.12	10.20
Potato	Agri	26.77	44.83	11.15	16.56	36.30	2.56

Note: M= Monthly Q=quarterly; Y =yearly; agri=agriculture; Ener=energy; NP=non-precious metals; Prec=precious metals; Envi=environmental products. Ahmd=Ahmedabad, MZFNR= Muzafernagar; Returns are in percentages.

Table 2.11: Monthly, Quarterly and Yearly Average Annualized Commodity Futures Nominal and Real Returns 2004 to 2014 - NCDEX Exchange (contd…)

Commodity-NCDEX	Sector	Nominal			Real		
		M	Q	Y	M	Q	Y
Polypropylene	Ener	13.52	8.36	1.65	7.04	2.22	-5.27
Black Pepper	Agri	25.05	34.31	24.46	17.37	25.53	17.40
PVC	Ener	8.53	18.22	18.19	1.93	10.50	11.79
PVC - Mumbai	Ener	10.40	13.32	10.25	4.08	6.97	3.33
RBD Palmolein	Agri	0.36	-5.81	3.05	-3.88	-10.93	-0.21
Rubber New	Agri	-18.44	9.46	20.93	-22.45	3.17	14.04
Rubber RSS 4	Agri	-18.44	9.46	20.93	-22.45	3.17	14.04
RM Oil	Agri	12.34	11.25	20.85	6.13	5.38	15.50
RM Seed	Agri	14.28	12.49	11.39	8.20	5.71	6.00
Rape Mustard Seed	Agri	8.23	13.90	12.29	8.20	5.71	6.00
Soymeal (Indore)	Agri	22.93	32.10	42.04	1.71	6.91	5.47
Soyameal Export	Agri	16.25	23.88	31.67	17.09	25.23	35.94
Sesame Seed	Agri	14.28	12.49	11.39	9.47	17.21	26.32
Shankar Kapas(Rajkot)	Agri	9.84	13.20	9.92	4.71	7.33	4.02
Silver	Prec	2.56	-1.89	-3.65	30.98	26.15	31.62
Silver 5 Kgs Ahmd	Prec	41.84	37.89	40.22	7.04	10.11	-8.79
Silver 5 Kgs	Prec	12.72	15.10	-3.44	-2.94	-7.99	-9.04
Silver5Kg Ahmd before 2008	Prec	22.36	19.38	0.06	14.57	11.99	-3.95
Steel Long (BIS 2830)	NP	3.96	3.95	5.83	-1.40	-1.80	-0.53
Steel Long	NP	3.96	3.95	5.83	-1.40	-1.80	-0.53
Sugar (M Grade)	Agri	-0.72	20.10	18.71	-7.35	12.52	11.20
Sugar (M Grade) MZFNR	Agri	-5.69	-19.08	-18.96	-10.08	-23.94	-22.97
Sugar (M Grade) Kolkata	Agri	-7.38	-19.22	-19.50	-11.99	-24.06	-23.51
Soya Bean	Agri	10.56	17.21	12.99	4.29	10.14	6.88
Soy oil-refined	Agri	4.10	8.44	4.82	-1.84	2.47	-1.29
Turmeric	Agri	22.73	30.01	29.49	15.98	22.37	23.39
Wheat	Agri	13.62	13.79	6.92	5.18	5.56	-1.25
Yellow Peas	Agri	13.03	14.37	20.15	6.64	9.41	14.80
Zinc	NP	7.01	5.72	24.26	-0.73	-1.93	16.50

Note: M= Monthly Q=quarterly; Y =yearly; agri=agriculture; Ener=energy; NP=non-precious metals; Prec=precious metals; Envi=environmental products. Ahmd=Ahmedabad, MZFNR= Muzaffernagar. ; Returns are in percentages.

Table 2.12: MCX and NCDEX's Monthly, Quarterly and Yearly Average Annualized Sector-wise Commodity Futures Nominal and Real Returns 2004 to 2014.

Sector/Exchange	Nominal (Inflation not adjusted)			Real (Inflation adjusted)		
MCX	Monthly	Quarterly	Yearly	Monthly	Quarterly	Yearly
Agriculture	21.37	24.20	16.09	13.64	17.06	9.28
Energy	15.13	20.37	18.33	7.33	11.58	10.88
Non-Precious Metals	7.83	8.67	6.79	1.87	2.18	1.03
Precious Metals	7.44	7.35	9.62	1.71	0.82	3.72
MCX's Overall	14.12	16.29	12.62	7.19	9.20	6.09
NCDEX						
Agriculture	13.85	15.41	15.59	7.21	8.68	9.80
Energy	11.30	15.53	7.76	4.87	8.71	1.47
Non-Precious Metals	6.13	7.78	5.23	-0.31	1.25	-1.40
Precious Metals	20.06	17.47	12.92	12.74	9.61	6.83
NCDEX's Overall	13.55	14.91	13.49	6.87	8.06	7.53

From table 2.8 to 2.12 and 2.2 the following can be inferred,

i) In the monthly frequency, the MCX's commodities such as Brent Crude, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapas, Menthaoil, Rubber, Tin, Turmeric and Urad are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Almond, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapaskhali, Lead, Lead Mini, Maize, Pepper, Refined Soyoil, Silver, Silver Mini, Soya bean, Thermal Coal, Wheat and Zinc Mini are offering higher returns than bonds, Treasury bills and inflation. On the other hand, Nickel, Aluminium Mini, Gold Petal, and Zinc are yielding higher returns than bonds and inflation, while, ATF is just slightly higher than Treasury bills. The overall mean return turnout to be 14.12 percent per annum. Similarly, the sector wise average returns indicate that all the four sectors are offering higher returns than the bonds, Treasury bills and inflation but lower than the equity except agriculture sector. The sectoral comparison reveals that agriculture is offering highest returns and then followed by energy, non-precious metals and precious metals. Inflation adjusted series also indicates more or less similar results.

ii) Similarly, the NCDEX's commodities such as Black Pepper, Chilli LCA334, Cotton Seed Oil cake Akola, Furnace oil, Gold 100grams, Gold Pure Mumbai Kg, Guar Gum , Masoor Bold, Potato, Raw Jute, RM seed oilcake, Silver 5Kg (Ahmedabad) before 2008, Silver 5Kgs (Ahmedabad), Soymeal (Indore) and Turmeric are offering higher returns than the equity, bonds, Treasury bills and inflation. On the other hand, Barley, Castor Seed, Copper before 2010, Cotton Seed Oilcake, Cotton Seed Oil cake (Kadi), Dhaniya, Groundnut (in shell), Ground nut Expeller Oil, Gur, Gur (Muzaffarnagar), Jeera, Jute Sacking, Medium Staple Cotton, Polypropylene, RM Oil, RM Seed, Sesame Seed, Silver 5Kgs, Soya Bean, Soya meal Export, V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. Whereas Brent Crude Oil, Castor, Chana, Coppersince2010, Crude Oil, Gold, PVC, PVC-Mumbai, Shankar Kapas (Rajkot) and Zinc are yielding higher returns than bonds and inflation. The overall mean return turnout to be 13.55 percent per annum and it is lower (0.57 percent) than the MCX' average return. Similarly, the sector wise average returns indicate that all the four sectors are offering higher returns than the bonds, Treasury bills and inflation but lower than the equity. The sectoral comparison reveals that precious metals are offering highest returns and then followed by agriculture, energy and non-precious metals. Inflation adjusted series also indicates more or less similar results.

iii) On the other hand, in the quarterly frequency MCX commodities such as Brent Crude, Cardamom, Chana, CPO, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapaskhali, Maize, Menthaoil, Pepper, Rubber, Soya bean, Thermal Coal, Tin, Turmeric, Urad and Wheat are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Almond, ATF, Chana-Delhi, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Gold Petal, Kapas, Lead Mini, Nickel, Refined Soyoil, Silver, Silver Mini, Sugar Mini-Kolkata and Zinc Mini are offering higher returns than bonds, Treasury bills and inflation. On the other hand, Natural Gas and Aluminium Mini are yielding higher than bonds and inflation and Zinc is just slightly higher than only inflation. The overall mean return turnout to be 16.29 percent per annum. Similarly, the sector wise average returns indicate that agriculture and energy sector's average returns are higher than the equity, bonds, Treasury bill and inflation whereas the precious and non-precious sector's average returns higher than the bonds, Treasury bills and inflation but lower than the equity

except agriculture sector. The sectoral comparison reveals that agriculture is offering highest returns and then followed by energy, non-precious metals and precious metals. Once again inflation adjusted series also indicates more or less similar results.

iv) Similarly, the NCDEX's quarterly commodity wise average returns indicates that commodities such as Black Pepper, Furnace oil, Gold 100grams, Gold Pure Mumbai Kg, Guar Gum, Jeera, Masoor Bold, Potato, Raw Jute, RM seed oilcake, Silver 5Kg (Ahmedabad) before 2008, Silver 5Kgs (Ahmedabad), Soya meal Export, Soymeal (Indore), Sugar (M-Grade) and Turmeric are offering higher returns than the equity, bonds, Treasury bills and inflation. On the other hand, Barley, Brent Crude Oil, Castor (Disa), Castor Seed, Chana, ChilliLCA334, Copperbefore2010, Coppersince2010, Cotton Seed Oilcake, Cotton Seed Oilcake Akola, Cotton Seed Oilcake (Kadi), Crude Oil, Dhaniya, Gold, Groundnut (in shell), Groundnut Expeller Oil, Gur, Gur (Muzaffarnagar), Medium Staple Cotton, Nickel, Polypropylene, PVC, PVC-Mumbai, Rape Mustard Seed, RM Oil, Rubber New, RubberRSS4, Sesame Seed, Shankar Kapas (Rajkot), Silver5Kgs, Soya Bean, Soy oil-refined, V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. Whereas Steel Long, Steel Long (BIS2830), Zinc are just higher than inflation. The overall mean return turnout to be 14.91 percent per annum and it is lower (1.38 percent) than the MCX' average return. Similarly, the sector wise average returns indicate that all the four sectors are offering higher returns than the bonds, Treasury bills and inflation but lower than the equity. The sectoral comparison reveals that precious metals are offering highest returns and then followed by energy and non-precious metals. Inflation adjusted series also indicates more or less similar results.

v) In the yearly frequency, the MCX commodities such as ATF, Cardamom, Gasoline, Guar Seed, Heating oil, Kapaskhali, Platinum, Rubber, Thermal Coal, and Turmeric are beating the equity, bonds, Treasury bills and inflation. On the other hand, Almond, Areca Nut Jhaji, Brent Crude, Chana-Delhi, Copper, CPO, Crude oil, Flake Menthol, Gold, Gold Guinea, Gold Mini, Kapas, Lead, Maize, Nickel, Pepper, Refined Soyoil, Silver, Silver Mini, Soya bean, Sugar Mini-Kolkata, Tin, Urad, Wheat and Zinc Mini are offering higher returns than bonds, Treasury bills and inflation. Whereas Chana and Menthaoil are offering higher returns than bonds and inflation and on the other hand,

Aluminium and Zinc are yielding only higher the inflation. Approximately similar results can be found in the inflation adjusted series also. The overall mean return turnout to be 12.62 percent per annum and it is much lesser than the monthly and quarterly frequency average returns. Similarly, the sector wise average returns indicate that all the four sectors are offering higher returns than the bonds, Treasury bills and inflation but lower than the equity except agriculture sector. The sectoral comparison reveals that agriculture is offering highest returns and then followed by energy, non-precious metals and precious metals. Inflation adjusted series also indicates more or less similar results.

vi) Similarly, the NCDEX's yearly commodity wise average returns indicates that commodities such as Black Pepper, Cotton Seed Oilcake Kadi, Dhaniya, Gold 100grams, Gold Pure Mumbai Kg, Guar Gum , Masoor Bold, RM Oil, RM seed oilcake, Rubber New, RubberRSS4, Silver5Kgs (Ahmedabad), Soya meal Export, Soymeal (Indore), Turmeric and Zinc are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Barley, Castor (Disa), Castor Seed, ChilliLCA334, Cotton Seed Oilcake Akola, Crude Oil, Furnace oil, Gold, Gur, Gur (Muzaffar Nagar), Jeera, Jute Sacking, Medium Staple Cotton, Nickel, Potato, PVC, PVC-Mumbai, Rape Mustard Seed, Raw Jute, RM Seed, Sesame Seed, Shankar Kapas (Rajkot), Soya Bean, Sugar(M-Grade) , V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. On the other hand, Chana, Groundnut (in shell), Soya oil-refined, Steel Long and Steel Long (BIS2830) are yielding higher than bonds and inflation. On the contrary, copper since 2010, Cotton Seed Oilcake, Ground nut Expeller Oil and RBD Palmolein is just slightly higher than inflation. Once again inflation adjusted series also indicates more or less similar results. The overall mean return turnout to be 13.49 percent per annum and it is higher (0.87 percent) than the MCX' average return. Similarly, the sector wise average returns indicate that all the sectors (except non-precious metals) are offering higher returns than the bonds, Treasury bills and inflation but lower than the equity. Though non-precious metals are offering higher returns than bonds and inflation but their returns are lower than equity and treasury bills. The sectoral comparison reveals that agriculture sector is offering highest returns and then followed by precious metals, energy and non-precious metals. Inflation adjusted series also indicates more or less similar results.

On the whole, commodity wise analysis indicates that on an average the MCX's commodities such as Brent Crude, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapas, Menthaoil, Rubber, Tin, Turmeric and Urad are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Almond, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapaskhali, Lead, Lead Mini, Maize, Pepper, Refined Soyoil, Silver, Silver Mini, Soya bean, Thermal Coal, Wheat and Zinc Mini are offering higher returns than bonds, Treasury bills and inflation. On the other hand, Nickel, Aluminium Mini, Gold Petal, and Zinc are yielding higher returns than bonds and inflation, while, ATF's returns are marginally higher than Treasury bills. Whereas commodities such as Aluminium, Areca Nut (Jhaji), CER, Copper Mini, Coriander, Cotton, CPO, Gold Petal (Delhi), Natural Gas, Nickel Mini, Platinum, Silver Micro, Sugar Mini (Kolkata) are not beating any of the traditional asset classes. Given the sectoral average returns, it is evident that there exists a sectoral bias. On an average, agriculture and energy sectoral commodity futures are offering much better returns compare to other sectors such as precious and non-precious metals. Quarterly frequency offers highest returns and then followed by monthly and yearly. This indicates that return holding frequency also matters.

Similarly, NCDEX's commodity wise analysis indicates that on an average commodities such as Black Pepper, Chilli LCA334, Cotton Seed Oil cake Akola, Furnace oil, Gold100Grams, Gold Pure Mumbai Kg, Guar Gum, Masoor Bold, Potato, Raw Jute, RM seed oilcake, Silver 5Kg (Ahmedabad) before 2008, Silver 5Kgs (Ahmedabad), Soymeal (Indore) and Turmeric are offering higher returns than the equity, bonds, Treasury bills and inflation. On the other hand, Barley, Castor Seed, Copper before 2010, Cotton Seed Oilcake, Cotton Seed Oil cake (Kadi), Dhaniya, Groundnut (in shell), Ground nut Expeller Oil, Gur, Gur (Muzaffar Nagar), Jeera, Jute Sacking, Medium Staple Cotton, Polypropylene, RM Oil, RM Seed, Sesame Seed, Silver 5Kgs, Soya Bean, Soya meal Export, V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. Whereas Brent Crude Oil, Castor, Chana, Coppersince2010, Crude Oil, Gold, PVC, PVC-Mumbai, Shankar Kapas (Rajkot) and Zinc are yielding higher returns than bonds and inflation. Whereas commodities such as Castor, Nickel, RBD Palmolein, Rubber New, Rubber RSS 4, Silver, Soy oil-refined, Steel Long, Steel Long (BIS 2830), Sugar (M Grade), Sugar (M Grade- Kolkata), Sugar (M Grade-Muzaffar Nagar) are not beating any of the traditional asset classes such as equity, bonds, Treasury bills and inflation. Given the sectoral average returns, it is evident that there exists a sectoral bias. On

an average, precious metals and agriculture commodity futures are offering much better returns compare to other sectors such as energy and non-precious metals. Similar to MCX, in the case of NCDEX also quarterly frequency offers highest returns and then followed by monthly and yearly. This indicates that return holding frequency also matters.

It is evident that on an average agricultural and energy products are offering much better returns on the MCX exchange and whereas in the case of NCDEX, precious metals and agricultural commodity contracts are offering much better returns compare to other sectoral commodity futures. In terms of returns holding, quarterly frequency offers highest returns and then followed by monthly and yearly.

2.5: Conclusion

This chapter provides evidence on the short and long-term properties of an investment in commodity futures contracts. In order to study commodity futures as an investible class of assets, we have constructed two types of equally-weighted indexes (first type of index includes all the commodity futures contracts and the second type includes only the commodity futures contracts which survived until December 2014) of commodity futures covering the period between January 2004 and December 2014.

Historical returns analysis indicates that the equally weighted rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index returns are lower than the equity index and this gap increases as we change the frequency from monthly (approximately 3 percent) to quarterly (approximately 5.5 percent) and then to yearly (approximately 5 percent). On the other hand, the equally weighed index is outperforming the bonds (by 11 percent, 9 percent and 11 percent monthly, quarterly and yearly respectively), Treasury bills (by 9 percent, 8 percent and 9 percent monthly, quarterly and yearly respectively) and inflation (by 9 percent, 11 percent and 13 percent monthly, quarterly and yearly respectively). The performance of the commercially available commodity futures indexes (such as MCX's Comdex, Agriculture, Energy and Metal) other than Dhaanya, are similar to the equally weighted commodity futures index compared to other asset classes. Where, Dhaanya index is yielding higher returns than the equally weighted index as well as equity also. However, these commercially available commodity futures indexes' returns are far below from the equally weighted commodity futures

index in all three frequencies. Equally weighted commodity futures which are constructed based on all contracts are found to be yielding higher returns in terms of nominal as well as real returns compared to indexes which are constructed using contracts which survived until December 2014 (on an average the difference is approximately 1 percent). So on an average the equally weighted commodity futures returns (irrespective of the re-balancing frequency) are lower than the equities but higher than bonds, Treasury bills and inflation. However, they are found to be offering the highest (based on Sharpe ratios) risk adjusted returns for the sample period in all three re-balancing frequencies. Compared to the quarterly re-balancing frequency (holding period), monthly and yearly re-balanced commodity futures yield higher returns and this is true in both types of equally weighted indexes. On the other hand, monthly first type (which includes all the futures contracts) equally weighted index is offering higher returns compared to yearly but this relationship is opposite in the case of the second type (which includes only the contracts which survived until December 2014) of equally weighted index. The gap between the two types of equally weighted commodity futures indexes shows that there is a survivor and exclusion bias in the Indian commodity futures markets and rebalancing frequencies does matter a lot.

It is also true that there exists a positive risk premium in the commodity futures, which is also statistically significant. This means, commodity futures are offering more returns than the risk free rate. The commodity futures risk premium is lower (on an average 4 percent) than the equity but much higher than bonds (on an average five to ten times). Though commodity futures are offering lower risk premium and risk adjusted returns (Sharpe ratios) compared to equity but they have a lower standard deviation. This means, though equity might be offering higher returns compared to commodity futures, they are too risky. On an average, commodity futures are offering positive returns most of the time, when compared to equity and bonds.

Though equities are yielding higher returns than commodity futures, their standard deviations are also much higher. This is true in all three re-balancing frequencies. In terms of skewness, the commodity futures returns are negatively distributed at the monthly and quarterly frequency whereas at the yearly frequency the direction is opposite (i.e. changed into positive direction). On the other hand, equity returns are negatively distributed in the case of monthly and yearly frequencies but positively distributed at the quarterly frequency. This indicates that in the case of positive skewness, returns have more weight in the right tails whereas, in the case of negative

skewness, returns have more weight in the left tails. Similarly, on an average, for all the assets class indexes kurtosis is less than 3 (except the quarterly Dhaanya index and yearly EWI1). This indicates that the probability for extreme returns is less than that for a normal distribution, and the returns are widely spread around the mean.

It is also evident that commodity futures returns are positively correlated with equity returns. The positive correlation between commodity futures and equity becomes stronger as we change the re-balancing frequency from monthly to quarterly and then to yearly. Contrary to equity, commodity futures are negatively correlated with bonds. The negative correlation between commodity futures and bonds is also statistically significant and it becomes weaker as the re-balancing frequency changes from monthly to quarterly and then to yearly. The negative correlation between commodity futures and bonds leads to better portfolio diversification. At times when either one of the asset classes is generating negative returns, simultaneously, the other asset class provides positive returns, hence on an average, the investor will be safe. The correlation between commodity futures and inflation is not in one direction. As the holding period changes from the monthly to quarterly and then to yearly frequency, commodity futures sensitivity to inflation and to its components (such as changes in inflation and unexpected inflation) switches from the positive to the negative regime and then falls back to the positive regime. However, equities and bonds continue to be negatively sensitive to changes to inflation and unexpected inflation, irrespective of the holding period. Since inflation is persistent over time, unexpected inflation often causes market participants to revise their estimates of future expected inflation in order to maintain the purchasing power of their returns. Revisions about future inflationary expectations have a positive influence on commodity futures but negative influence on equities and bonds. On the whole, commodity futures have an opposite exposure in the monthly and yearly but the same exposure in the case of quarterly frequencies. So, the commodity futures are a better hedge against inflation given the changes in the inflation components.

Commodity wise analysis indicates that on an average the MCX's commodities such as Brent Crude, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapas, Menthaoil, Rubber, Tin, Turmeric and Urad are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Almond, Copper, Crude oil, Gold, Gold Guinea,

Gold Mini, Kapaskhali, Lead, Lead Mini, Maize, Pepper, Refined Soyoil, Silver, Silver Mini, Soya bean, Thermal Coal, Wheat and Zinc Mini are offering higher returns than bonds, Treasury bills and inflation. On the other hand, Nickel, Aluminium Mini, Gold Petal, and Zinc are yielding higher returns than bonds and inflation, while, ATF's returns are marginally higher than Treasury bills. Whereas commodities such as Aluminium, Areca Nut (Jhaji), CER, Copper Mini, Coriander, Cotton, CPO, Gold Petal (Delhi), Natural Gas, Nickel Mini, Platinum, Silver Micro, Sugar Mini (Kolkata) are not beating any of the traditional asset classes.

Similarly, NCDEX's commodity wise analysis indicates that on an average commodities such as Black Pepper, Chilli LCA334, Cotton Seed Oil cake Akola, Furnace oil, Gold100Grams, Gold Pure Mumbai Kg, Guar Gum, Masoor Bold, Potato, Raw Jute, RM seed oilcake, Silver 5Kg (Ahmedabad) before 2008, Silver 5Kgs (Ahmedabad), Soymeal (Indore) and Turmeric are offering higher returns than the equity, bonds, Treasury bills and inflation. On the other hand, Barley, Castor Seed, Copper before 2010, Cotton Seed Oilcake, Cotton Seed Oil cake (Kadi), Dhaniya, Groundnut (in shell), Ground nut Expeller Oil, Gur, Gur (Muzaffar Nagar), Jeera, Jute Sacking, Medium Staple Cotton, Polypropylene, RM Oil, RM Seed, Sesame Seed, Silver 5Kgs, Soya Bean, Soya meal Export, V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. Whereas Brent Crude Oil, Castor, Chana, Coppersince2010, Crude Oil, Gold, PVC, PVC-Mumbai, Shankar Kapas (Rajkot) and Zinc are yielding higher returns than bonds and inflation. Whereas commodities such as Castor, Nickel, RBD Palmolein, Rubber New, Rubber RSS 4, Silver, Soy oil-refined, Steel Long, Steel Long (BIS 2830), Sugar (M Grade), Sugar (M Grade- Kolkata), Sugar (M Grade-Muzaffar Nagar) are not beating any of the traditional asset classes such as equity, bonds, Treasury bills and inflation. It is evident that on an average agricultural and energy products are offering much better returns on the MCX exchange and whereas in the case of NCDEX, precious metals and agricultural commodity contracts are offering much better returns compare to other sectoral commodity futures. In terms of returns holding, quarterly frequency offers highest returns and then followed by monthly and yearly.

On the whole, we find that (evident from equally weighted index as well as commodity wise analysis) commodity futures are beating bonds, Treasury bills and inflation but are underperforming compared to equity in terms of returns and the risk premium. However, they are

offering the highest risk adjusted returns (Sharpe ratios) compared to all the investible class of assets under study. On an average, commodity futures are offering positive returns most of the time and are less volatile, compared to equity. Commodity futures are negatively correlated with bonds but positively correlated with equity, and inflation and its components, such as changes in inflation and unexpected inflation. A negative correlation with bonds makes the commodity futures a better diversifiable asset and the positive correlation with inflation and its components makes these assets a better hedge against inflation. Hence, based on all these advantages, we say that the Indian commodity futures are an investible class of assets and they are the next best alternative to the equity in India given their relative position in terms of returns performance compared to all other investible class of assets in India.

CHAPTER 3

RISK AND RETURN RELATIONSHIP IN THE INDIAN COMMODITY FUTURES MARKETS

3.1: Introduction

It is well known that the financial markets can be cold, chaotic. So in order to be successful, the investor should know the relationship between the risk and return of his/her portfolio interest (invested) in the financial markets. In the world of finance, risk is measured as the deviation from the expected returns or from the statistical (technical) point of view it is measured in terms of the standard deviation. From the practical point of view risk is known as the possibility of losing some portion of the investment or full amount of the investment. Finance literature has established that higher returns are associated with higher risk, but the same is not necessarily true all the time. It is one of the possibilities that the higher risk yields higher returns.

The risk taking levels vary from person to person and market to market, which means it is not uniform across investors and markets. Depending upon the investor's preferences, markets have been emerging such as the treasury market, bond market, equity market, commodity markets, money markets, derivatives (financial and commodity) and many more. The existence of these different markets gives ample opportunities for investors to invest across a diverse spectrum of investible class of assets.

In general, financial markets across the globe have shown a strong volatile character. Financial products are influenced by multiple factors that include domestic factors and international factors. Among the domestic factors, we may list central bank monetary and credit policies, tax structure, political and economic policies, changes in demand and supply, regulatory policies and at the international level, trade policy, currency value appreciation and depreciation and many other factors. Commodity and financial derivatives have emerged as the risk minimizing tools in the modern day investment world. They also offer other benefits such as price discovery and liquidity enhancement in the portfolio.

Though it is believed[7] that trading in the commodity markets originated between 4500 BC and 4000 BC, commodity derivatives as a tool for risk management have been recognized in recent centuries after the establishment of the Dojima rice futures markets in Japan in the 18th century and the Chicago Board of trade (CBOT) in 1848 to trade forwards in agricultural commodities and trading in cotton through the Cotton Trade Association in 1875 in India. Although, commodity and commodity derivatives markets have such a long history, the revival in trading in commodities and commodity derivatives regained momentum after the oil price shocks in the 1970s.

In this study, we examine whether there is any systematic risk in the Indian commodity derivative markets or not. According to Keynes (1930) futures prices are not constant over time and they are quite variable, hence hedgers pay the risk premiums to speculators for taking the risk which arises due to futures price volatility. But according to portfolio theory, portfolio diversification nullifies the rewards for all the price risks (Chang et al., 1990).

On the other hand, the Sharpe (1964) and Lintner (1965) Capital Asset Pricing Model (CAPM) asserts that only financial markets offer rewards for systematic risk in the case of financial assets. Whether speculators bear any systematic risks and whether there is an average reward commensurable to the systematic risks of futures contracts have been studied by Dusak (1973), Carter et al. (1983), Marcus (1984), Baxter et al. (1985), So (1987), Elam and Vaught (1988), and Chang et al. (1990), among others.

Using the CAPM model, Dusak (1973) concludes that the systematic risks of owning wheat, soybean and corn futures contracts were near zero over the period 1952 to 1967 and also claims that these futures contracts are not risky assets when they are held as part of a large portfolio of assets. Carter et al. (1983) modified the Dusak study in two ways - introducing the stochastic systematic risk as a function of actual net speculative positions, and constructing the market portfolio by allowing 50 percent of S&P stock index and rest of the 50 percent consisting of the Dow-Jones commodity futures index. They conclude that 50 percent of the futures contracts had positive systematic risk. Marcus (1984) criticizes the findings of the Carter et al. study (1983)

[7] http://forbesindia.com/printcontent/34515

and argues that the results of the study negate Dusak's study due to inappropriate market portfolio index construction.

On the other hand, Baxter et al. (1985) challenge the findings of the Carter et al. (1983) study. Essentially Baxter et al. (1985) replicate the Dusak (1985) study by modifying the market portfolio to 93.7 percent of the S&P 500 index and 6.3 percent of the Dow-Jones cash commodity index. Surprisingly, they find that none of the futures contract coefficients are positively significant. On the whole, it is clear that due to the modification (change) in the market portfolio, their results contradict those of Carter et al. (1983) and support the findings of the Dusak (1973) study. Similarly, So (1987) also could not find any positive systematic risk for wheat, soybean, and corn futures contracts during the 1953 to 1976 sample period.

On the contrary, Elam and Vaught (1988) report low but positively significant systematic risks in the case of cattle and hog futures contracts. Similarly Chang et al. (1990) also confirm the existence of positive and significant systematic risk for the copper, platinum and silver futures contracts over the 1978 to 1983 time period.

From the above literature review it is clear that there is no consensus as to whether there exists a positively significant systematic risk or not in the commodity futures. Given the divergent views on the existence of systematic risk in the commodity futures contracts, the present study employs the modified Capital Asset Pricing Model (CAPM) and Consumption CAPM models to test whether there exists any systematic risk in the Indian commodity futures markets or not.

3.2: Data and Methodology

3.2.1: Data description

This study utilizes the monthly commodity futures contracts data drawn from the National Commodity and Derivatives Exchange (NCDEX) and Multi Commodity Exchange (MCX). The reason for focusing only on these two exchanges is that they constitute about 96.19 [8]percent of the total commodity futures market in India. The sample period starts from January 2004 to December 2014. We have applied a filter in selecting the sample using the criterion that if a commodity futures contract trades at least fifty four (54) months continuously then that

[8]Forward Market Commission annual report (2013-14).

commodity futures contract is included in the sample otherwise it will be excluded (the idea behind choosing the minimum 54 months criteria is that we lose the first 24 observations in the rolling, at least we will retain 30 observations for estimation, which is a good number of observations for time series analysis). After applying the criterion, we ended up with 35 commodity futures contracts from the MCX and 45 futures contracts from NCDEX. CNX Nifty has been used as a proxy for the market portfolio.

In the following sections, we provide the empirical evidence on the existence of systematic risk, and then we estimate the risk premium in terms of the market beta and consumption beta using the (modified) capital asset pricing model. Essentially this chapter is trying to address the question of whether there is a systematic risk in the Indian commodity futures markets or not? If yes, then is it priced or not? We also estimate the risk premium in terms of the market beta and consumption beta.

3.2.2: Systematic Risk Estimation

Sharpe (1964) and Lintner (1965) developed the Capital Asset Pricing Model (CAPM) to explain the prices of capital assets such as equities. According to the CAPM, investors should be compensated in two ways: time value of money (compensates the investors for parking their money in any investment and is represented by the risk free rate) and market risk premium (for taking additional risk).

$$E(R_i) = R_f + \beta(E(R_m) - R_f) \qquad (3.1)$$

WhereR_i is the return on ith asset. $R_f$is the risk free rate of interest. R_m is the return on the market portfolio. Equation (3.1) tells us that the expected return on an asset is the sum of the risk free interest rate and product of the systematic risk of asset (β) and the risk premium on the market portfolio $(R_m - R_f)$. Here the systematic risk is defined as the contribution an asset makes to the risk of the market portfolio (Dusak, 1973 and Elam and Vaught, 1988).

Following the literature (Dusak, (1973), Bodie et al. (1980), and Elam and Vaught (1988)), we employ the following modified CAPM model:

$$E(R_i) = \beta(E(R_m) - R_f) \qquad (3.2)$$

In equation (3.2), we have not included the risk free interest rate as an intercept. The underlying idea is that when an investor purchase of a share (stock) calls for immediate payment whereas a futures contract represents an agreement to buy a commodity at some time in future. When a futures contract is bought, only a portion of the value of the futures contract (5 to 15 percent) is put up as margin. By contrast, 100 percent of the price of a stock is paid when the stock is purchased. Because the payment for a stock is made up front, the return on a stock should reflect the time value of money. The return on a futures contract should not the include risk free interest rate because essentially no money is put up to buy the futures contract. This means that the return on an equity with comparable riskiness to that of a commodity represented by a futures contract should be at least as much as the risk free rate, thus the greater the return for the commodity futures contract.

In order to capture the systematic risk we estimate the following equation. The null hypothesis is that there is no systematic risk in Indian commodity futures during the sample period.

$$R_{i,t} = \alpha + \beta RM_{i,t} + \varepsilon_{i,t} \qquad (3.3)$$

where α and β are fixed parameters and ε_t a stochastic error term. R_t is the commodity wise monthly return and RM is the market premium for commodity futures which trades on the MCX and NCDEX over the sample period.

Thus, the model (3.3) relates the return on the commodity futures contract to its systematic risk βRM_t. If the βRM_t, for each commodity futures contract is directly observable, then we could have run the regression which is specified in model (3.3), however the market beta (βRM_t) is not observable. Following the CAPM literature, we use the sample estimates. That is, for each commodity futures contract, we use the time series of returns R_t and R_m to estimate βRM_t on a twenty four (24) month rolling window following the general convention in the literature. We then use the estimated βRM_t as the variable in the model (represented by equation (3.3)).

3.2.3: The Consumption CAPM

The standard traditional capital asset pricing model relates the expected return on an asset to its systematic risk (i.e., risk of an asset by assets covariance with the stock market index return). Following the literature (See Jagannathan (1985); Mankiw and Shapiro (1986); Asprem(1989);

Chen (2003); Jagannathan and Wang (2005); Parker and Julliard (2005); Szymanowska and Roon (2007)), we employ the following model to compute the consumption beta:

$$R_{i,t} = \alpha + \beta C_{i,t} + \varepsilon_{i,t} \qquad (3.4)$$

where α and $\beta$are fixed parameters and ε_t is a stochastic error term. R_t is the commodity wise monthly return and $C_{i,t}$ is the consumption growth. Since in India we do not have high frequency (neither monthly nor quarterly) per capita consumption data, following Asprem (1989) and Chen (2003) we use the monthly imports data as a proxy for consumption expenditure to alternatively examine the consumption CAPM. The idea behind using imports as a proxy for consumption is that changes in consumption and investment trigger changes in imports. Increase in the domestic private consumption could lead to an increase in imports. Changes in imports over time compared to consumption should better capture the volatility in stock prices. Consequently, changes in imports could be a good proxy for the changes in consumption and hence it is a useful indicator of changes in people's preferences towards consumption and savings (Asprem, 1989).

In order to see (check) which measure of the risk model (traditional CAPM (i.e. market beta) versus consumption CAPM (consumption beta)) better explains commodity futures returns in India, we combine both the traditional CAPM and consumption CAPM models into a single equation and estimate the same as specified below. The null hypothesis is that there is no systematic risk in the Indian commodity futures during the sample period.

$$R_{i,t} = \alpha + \beta_1 RM_{i,t} + \beta_2 C_{i,t} + \varepsilon_{i,t} \qquad (3.5)$$

The constant coefficient α in equations 3.3, 3.4 and 3.5 has the following interpretation: that commodity futures yield a constant risk free return and both the market and consumption betas are equal to zero. Each CAPM beta implies that the coefficient on the relevant beta is the spread between the market return and the risk free return (Mankiw and Shapiro (1986)). The null hypothesis in the above equation (3.5) is that according to the traditional capital asset pricing model the $\beta_1 = ER_m - R_f$ and $\beta_2 = 0$, while the consumption CAPM implies that $\beta_1 = 0$ and $\beta_2 = ER_m - R_f$.

3.3: Results and Discussion

In this section we report the exchange wise and combined exchanges (Futures) estimated risk premium betas of the traditional CAPM (market beta) and consumption CAPM (consumption beta) models.

3.3.1: Do High Market Beta Commodity Futures Contracts Earn Higher Returns?

The general implication of any version of the capital asset pricing model is that assets with higher betas (i.e. higher systematic risk) earn higher average returns. By following the same implication, we examine the exchange wise cross section as well as time series properties of the commodity futures contract's returns series to determine whether this positive relationship exists or not in Indian commodity futures markets for the period January 2004 to December 2014.

The regression coefficients in table 3.1A indicate that there is a positive relationship between the commodity futures contracts and its market beta in the case of the combined exchanges unique commodity futures contracts (Futures) only. However, the MCX and NCDEX coefficients are positive but not statistically significant. These results indicate that, in general in the Indian commodity futures markets, there exists a positive market beta of 0.5 percent (i.e. systematic risk) over the sample period. The slope coefficient is positive and half of the market beta. From this we can say that commodity futures in India move along with the general market but half in the size.

Table 3.1A: Exchange Wise Cross Section-Estimated Market Beta

	Market Beta		Constant		R^2
Futures	0.50***	[4.29]	1.24***	[9.90]	0.22
MCX	0.45	[1.46]	1.15***	[2.76]	0.29
NCDEX	0.51	[0.90]	1.38***	[3.41]	0.18

Note: Robust z-statistics in brackets. ***, **, * represents statistical significance at the 1%, 5% and 10% levels; MCX stands for Multi Commodity Exchange of India Ltd; NCDEX stands for National Commodity & Derivatives Exchange Limited ; Futures means that commodities futures contracts should be unique to either of the exchanges.

Exchange (MCX and NCDEX) level time series properties of the commodity futures contract wise market beta (traditional capital asset pricing model) analysis from tables 3.1B, 3.1C and 3.1D indicate that eight out of thirty five commodity futures are significant on the MCX exchange and five out of forty five commodity futures are significant on the NCDEX exchange. Among the statistically significant commodity futures on the MCX, Brent Crude Oil, Crudeoil, Guar gum, Nickel, Tin and Turmeric are positively related to its market beta and Guar seed and Steel Flat are negatively related to its market beta. These positive betas range from 0.43 percent to 10.85 percent and the positive average beta turns out to be 5.72 percent, whereas the negative beta ranges from -30.76 percent to -4.92 percent of the MCX exchange and negative average beta turns out to be -17.84 percent. On the other hand, on the NCDEX exchange, Light Sweet Crude Oil, Soymeal (Indore) are positively related to its market beta and Castor Seed (Disa), Castor Seed, Indian 31 MM Cotton are negatively related to its market beta. The positive betas range from 1.54 percent to 5.19 percent and negative betas ranges from -35.29 percent to -8.97 percent. The average positive beta on NCDEX turns out to be 3.36 percent and average negative beta turns to be -19.07 percent.

Though MCX's commodities such as Pepper, Maize, Cardamom, Mentha Oil, Potato (Tarkeshwar), Aluminium, KapasiaKhalli, Red Chilli and Natural gas and on the other hand, NCDEX's commodities such as Mentha Oil (Chandausi), Cashew (Kollam), Guar Gum, Maize (Nizamabad), Gold Kg (Mumbai), Chilli (Guntur), Furnaceoil, Coriander (Kota), Zinc, Pepper (Kochi), Barley, Silver (Delhi), Guarseed, RBD Palm Olein (Kakinada), Masoor Grain Bold, Turmeric (Nizamabad) and Silver (Ahemadabad) possess negative market beta coefficients but they are not statistically significant. Purely based on the market beta coefficients direction (not statistically) we can interpret that these commodities serves as insurance against a drop in the market returns. If someone adds these negative market beta commodities to their portfolio reduces the overall portfolio risk.

Similarly, MCX's commodities such as Wheat, Rubber, Lead, Silver Mini, Copper, Silver, CPO, Refinde Soy Oil, Gold, Gold Mini, Potato, Zinc Mini, Zinc, Gold Guinea, Kapas, Soyabean, Carbon (CFI) and Lead Mini and on the other hand, NCDEX's commodities such as Medium Staple Cotton, Crude Palm Oil (Kandla), Refined Soy Oil (Indore), Jeera, Gur (Muzaffar Nagar), Kapas, Cotton Seed Oilcake (Akola), Soy Bean (Indore), Steel Long, Yellow Soybean Meal,

Wheat (Delhi), Shankar Kapas (Rajkot), Brent Crude Oil, Copper, Rubber New (Kochi), Mustardseed (Jaipur), Chana (Delhi), Nickel, Aluminium, Potato, Sugar M Grade (Kolhapur), R M Oil (Sri Ganga Nagar) and Raw Jute (Kolkata) possess positive market beta coefficients but they are not statistically significant. Once again purely based on the market beta coefficients direction (not statistically) we can interpret that these commodities on an average are very risky given their market beta levels. These commodities offers much higher returns whenever market returns are increasing and offers lower returns whenever the market is in the downside. These commodities are very well suited for the risk lovers.

On the whole at the exchange level irrespective of the statistical significance, the MCX exchange has an average market beta of 0.87 percent and the NCDEX has an average market beta of -1.12 percent. These exchange level (MCX (0.87) and NCDEX (-1.12) time series average market betas differ significantly from the exchange wise cross section MCX (0.45) and NCDEX (0.51) average market betas as well as the combined exchanges unique commodity futures contracts Futures (0.50). Since the overall Indian commodity future's market beta is positive (0.50) and this indicates that on an average Indian commodity futures returns move along with the (equity) market and commodity future's returns increases by half whenever the market value increases and decreases by half whenever the market value decreases since the beta coefficient is 0.5. Exchange wise analysis indicates that MCX's market beta is positive (0.87) and this indicates that on an average MCX's commodity futures returns move along with the market and commodity future's returns increases whenever the market value increases and decreases whenever the market value decreases since the beta coefficient is approximately one (0.87). On the other hand, NCDEX's market beta is negative (-1.12) and this negative betas indicates that on an average NCDEX's commodities serves as insurance against a drop in the market returns. If someone adds these negative market beta commodities to their portfolio reduces the overall portfolio risk. The NCDEX's average beta values are quite contrasting to the exchange wise cross section betas. Since the main focus is at the commodity level and all our conclusions will made on the basis of commodity betas only.

Table 3.1B: Time Series-Estimated Market Beta- MCX Exchange

Commodity	M-Beta	t-stat	Constant	t-stat	R^2	Obs
Aluminium	-2.05	-0.49	0.54	0.72	-0.92	85
Brent Crude Oil	5.85*	1.95	1.33	0.96	3.70	74
Cardamom	-5.38	-0.95	2.80	1.31	-0.12	83
Carbon (CFI)	8.07	1.33	-3.74	-1.58	2.20	35
Copper	2.24	0.69	0.53	0.63	-0.55	95
CPO	2.28	1.06	0.32	0.38	0.16	78
Crudeoil	4.24*	1.80	0.54	0.58	2.33	95
Gold	2.69	1.30	1.55***	2.84	0.64	108
Gold Guinea	5.67	1.65	1.97**	2.13	3.06	56
Gold Mini	3.67	1.49	1.73***	2.91	1.14	108
Guargum	0.43*	1.95	-0.94	-0.50	6.68	40
Guarseed	-4.92*	-1.82	2.61	1.56	2.69	85
Kapas	5.75	1.25	1.25	1.39	0.62	90
KapasiaKhalli	-1.41	-0.37	0.95	1.15	-0.91	97
Lead	1.26	0.27	0.04	0.02	-1.17	81
Lead Mini	9.91	1.25	-0.53	-0.39	1.87	31
Maize	-5.59	-1.02	1.53	1.64	0.06	59
Mentha Oil	-4.11	-0.84	1.63	1.13	-0.32	93
Naturalgas	-0.89	-0.23	-0.81	-0.53	-1.24	78
Nickel	8.09*	1.72	-2.44	-1.22	1.98	98
Pepper	-13.82	-0.71	6.18	1.04	-1.30	40
Potato	3.83	0.85	0.90	0.34	-0.43	68
Potato (Tarkeshwar)	-3.03	-0.67	3.21	0.58	-1.69	34
Red Chilli	-1.33	-0.76	1.28	0.49	-1.48	30
Refinde Soy Oil	2.64	0.49	1.11*	1.74	-0.95	81
Rubber	0.99	0.13	1.69	1.17	-1.53	66
Silver	2.24	0.66	0.68	0.54	-0.53	108
Silver Mini	1.72	0.59	0.89	0.75	-0.62	107
Soyabean	6.99	0.62	3.81	0.85	-2.03	32
Steel Flat	-30.76***	-3.74	0.06	0.05	30.21	31
Tin	10.85*	1.81	-0.51	-0.27	3.73	60
Turmeric	4.88**	2.28	6.25***	2.77	9.25	42
Wheat	0.49	0.15	1.37	1.42	-2.38	43
Zinc	4.79	1.02	-0.45	-0.34	0.05	82
Zinc Mini	4.08	0.64	0.48	0.39	-1.93	32

Note : Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. M-Beta= market beta.obs=number of observations.

Table 3.1C: Time Series-Estimated Market Beta- NCDEX Exchange

Commodity	M-Beta	t-stat	Constant	t-stat	R^2	Obs
Aluminium	8.69	0.62	0.26	0.17	-2.03	32
Barley	-3.04	-0.60	0.86	0.96	-0.90	73
Brent Crude Oil	3.79	1.45	0.96	1.01	1.28	85
Castor Seed (Disa)	-35.29**	-2.54	2.68**	2.54	13.12	37
Castor Seed	-8.97*	-1.73	-2.67	-1.22	4.42	44
Chana (Delhi)	6.80	1.12	1.36	1.43	0.25	98
Chilli (Guntur)	-7.13	-1.47	2.68	1.60	1.59	73
Cotton Seed Oilcake (Akola)	2.68	0.59	1.85	0.84	-1.62	42
Copper	4.20	0.94	-0.53	-0.51	-0.30	40
Indian 31 MM Cotton	-12.96*	-1.76	0.33	0.32	8.08	30
Medium Staple Cotton	0.20	0.02	0.85	0.70	-3.85	30
Crude Palm Oil (Kandla)	0.51	0.16	0.85	0.97	-1.48	68
Light Sweet Crude Oil	5.19**	2.62	0.56	0.64	8.37	65
Cashew (Kollam)	-9.68	-1.37	0.12	0.12	2.83	31
Coriander (Kota)	-4.84	-0.75	4.07*	1.89	-0.84	53
Furnaceoil	-6.91	-0.87	3.27	1.12	-0.95	30
Guar Gum	-8.78	-1.21	3.99**	2.18	0.69	68
Guarseed	-2.25	-0.27	3.99**	2.43	-1.35	71
Gold Kg (Mumbai)	-7.45	-0.74	2.41**	2.11	-1.32	36
Gur (Muzaffar Nagar)	1.95	0.28	-0.07	-0.06	-1.51	63
Jeera	1.20	0.33	1.17	1.03	-0.95	95
Raw Jute (Kolkata)	14.80	1.18	-0.43	-0.18	0.95	41
Kapas	2.65	0.90	1.24	1.04	-0.25	77
Maize (Nizamabad)	-7.95	-0.94	1.34	1.31	-0.28	44
MasoorGraing Bold	-1.91	-0.12	1.94	0.93	-4.10	30
Mentha Oil (Chandausi)	-31.53	-1.60	-0.48	-0.22	5.61	30
Nickel	7.69	0.98	-1.61	-0.56	-0.20	30
Potato	8.89	0.59	-6.33	-0.44	-2.67	30
Pepper (Kochi)	-3.15	-0.53	2.76**	2.07	-0.86	85

Note: Robust z-statistics in brackets. ***, **, * represents statistical significance at the 1%, 5% and 10% levels. M-Beta= market beta. Obs= number of observations.

Table 3.1D: Time Series-Estimated Market Beta - NCDEX Exchange (contd…)

Commodity	M-Beta	t-stat	Constant	t-stat	R^2	Obs
RBD Palmolein (Kakinada)	-2.00	-0.32	0.48	0.49	-1.79	52
Rubber New (Kochi)	4.35	1.17	0.91	0.85	0.70	53
R M Oil (Sri Ganga Nagar)	11.44	0.74	1.37	0.85	-1.77	30
Mustardseed (Jaipur)	6.62	1.21	2.22	1.12	1.82	30
Soymeal (Indore)	1.54*	1.86	3.73**	2.30	3.55	68
Yellow Soybean Meal	3.18	0.25	1.19	0.42	-2.92	34
Shankar Kapas (Rajkot)	3.59	0.60	2.58	0.93	-1.50	44
Silver (Ahemadabad)	-0.47	-0.10	-1.47	-0.88	-4.12	30
Silver (Delhi)	-2.49	-0.31	2.79	0.76	-3.01	32
Steel Long	3.04	1.21	0.13	0.19	0.94	49
Sugar M Grade (Kolhapur)	9.84	1.34	0.93	1.07	1.68	48
Soy Bean (Indore)	2.91	0.66	1.28*	1.67	-0.53	108
Refined Soy Oil (Indore)	0.64	0.18	0.82	1.35	-0.98	101
Turmeric (Nizamabad)	-1.59	-0.43	2.17	1.46	-0.81	102
Wheat (Delhi)	3.18	0.60	1.62	1.51	-1.29	51
Zinc	-3.17	-0.17	1.43	0.20	-4.22	30

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. M-Beta= market beta; obs=number of observations.

3.3.2: Do High Consumption Beta Commodity Futures Contracts Earn Higher Returns?

In this section we examine the empirical relationship between the commodity futures (the exchange wise cross section and time series) returns and consumption beta over the period January 2004 to December 2014. The regression coefficients in table 3.2A indicate that there is a positive relationship between commodity futures contracts and its consumption beta in the case of combined exchanges unique commodity futures contracts (Futures) and MCX exchange. However, the NCDEX coefficient is positive but not statistically significant. These results indicate that in general, in the Indian commodity futures markets; there exists a positive consumption beta of 0.33 percent (i.e. systematic risk) over the sample period. The slope coefficient is positive once again and one third of the market beta. From this we can say that

commodity futures in India move along with the general market but only one third in terms of the size of the market.

Table 3.2A: Exchange Wise Cross Section - Estimated Consumption Beta

	Consumption Beta		Constant		R^2
Futures	0.33***	[8.08]	1.24***	[9.79]	0.20
MCX	0.27***	[6.49]	1.18***	[2.88]	0.30
NCDEX	0.64	[0.82]	1.33***	[3.24]	0.14

Note: Robust z-statistics in brackets. ***, **, * represents statistical significance at the 1%,5% and 10% levels; MCX stands for Multi Commodity Exchange of India Ltd; NCDEX stands for National Commodity & Derivatives Exchange Limited ; Futures means that commodities futures contracts should be unique to either of the exchanges. All the coefficients are in percentages.

Exchange (MCX and NCDEX) level time series properties of the commodity futures contract wise consumption beta (consumption growth is proxied by imports growth) analysis from tables 3.2B, 3.2C and 3.2D indicate that four out of thirty five commodity futures are significant on the MCX exchange and six out of forty five commodity futures are significant on NCDEX exchange. Among the statistically significant commodity futures on the MCX, Brent Crude Oil, Guar seed and Turmeric are positively related to its consumption beta and Steel Flat is negatively related to its consumption beta. These positive betas range from 0.35 percent to 7.05 percent and the statistically significant positive average beta turns out to be 4.20 percent, whereas the negative beta turns out to be -26.17 percent. On the other hand, on the NCDEX exchange, Crude Palm Oil (Kandla), RBD Palmolein (Kakinada), Rubber New (Kochi), Silver (Delhi), Steel Long are positively related to its consumption beta and Guar seed is negatively related to its consumption beta. The positive betas range from 5.10 percent to 28.46 percent whereas the negative beta turns out to be -30.03 percent. The average statistically significant positive beta on the NCDEX turns out to be 16.87 percent and average negative beta turns to be -30.03 percent.

Though MCX's commodities such as Potato (Tarkeshwar), Pepper, Lead Mini, Gold Guinea, Gold, Zinc Mini, Cardamom, Gold Mini, CPO, Silver, Kapasia Khalli, Potato and Zinc and on the other hand, NCDEX's commodities such as Yellow Soybean Meal, Mustard seed (Jaipur), Medium Staple Cotton, Guar Gum, Castor Seed (Disa), Indian 31 Mm Cotton, Cashew (Kollam), Furnace oil, Potato, Masoor Grain Bold, Gold Kg (Mumbai), Gur (Muzaffar Nagar), Zinc, Jeera, Shankar Kapas (Rajkot), Sugar M Grade (Kolhapur), Turmeric (Nizamabad), Cotton Seed Oilcake(Akola), Soy Bean (Indore) and Chana (Delhi) possess negative consumption beta

coefficients but they are not statistically significant. Purely based on the consumption beta coefficients direction (not statistically) we can interpret that these commodities serves as insurance against a drop in the market returns. If someone adds these negative consumption beta commodities to their portfolio reduces the overall portfolio risk.

Similarly, MCX's commodities such as Mentha Oil, Maize, Crude oil, Carbon (CFI), Refined Soy Oil, Wheat, Natural gas, Soya bean, Guar gum, Red Chilli, Tin, Copper, Nickel, Rubber, Aluminium, Lead, Silver Mini and Kapas and on the other hand, NCDEX's commodities such as Light Sweet Crude Oil, Wheat (Delhi), Brent Crude Oil, Coriander (Kota), Barley, Soymeal (Indore), Refined Soyoil (Indore), Pepper (Kochi), Raw Jute (Kolkata), Mentha Oil (Chandausi), Chilli (Guntur), Castor Seed, Nickel, Kapas, Copper, Aluminium, Silver (Ahemadabad) and R M Oil (Sri Ganga Nagar) possess positive market beta coefficients but they are not statistically significant. Once again purely based on the consumption beta coefficients direction (not statistically) we can interpret that these commodities on an average are very risky given their consumption beta levels. These commodities offers much higher returns whenever market returns are increasing and offers lower returns whenever the market is in the downside. These commodities are very well suited for the risk lovers.

On the whole at the exchange level irrespective of statistical significance, the MCX exchange has an average consumption beta of -1.28 percent and the NCDEX has an average consumption beta of -0.23 percent. These exchange level (MCX (-1.28) and NCDEX (-0.23)) time series average consumption betas differ significantly from the exchange wise cross section analysis (MCX (0.27) and NCDEX (0.64)) average market betas as well as the combined exchanges unique commodity futures contracts (Futures (0.33)). Since the overall Indian commodity future's consumption beta is positive (0.33) and this indicates that on an average Indian commodity futures returns move along with the (equity) market and commodity future's returns increases by one third whenever the market value increases and decreases by one third whenever the market value decreases since the beta coefficient is 0.33. On the other hand, exchange wise average betas are negative (MCX (-1.28) and NCDEX (-0.23)). Once gain similar to market beta analysis, the consumption exchange betas are quite contrasting to the exchange wise cross section betas. Since the main focus is at the commodity level and all our conclusions will made on the basis of commodity betas only.

Table 3.2B: Time Series-Estimated Consumption Beta - MCX Exchange

Commodity	C-Beta	t-stat	Cons	t-stat	R^2	Obs
Aluminium	4.17	0.84	-0.29	-0.27	-0.34	85
Brent Crude Oil	5.19**	2.13	0.08	0.06	4.64	74
Cardamom	-4.25	-0.97	0.84	0.54	-0.06	83
Carbon (CFI)	0.31	0.08	-1.34	-0.86	-3.01	35
Copper	3.08	0.71	0.29	0.29	-0.53	95
CPO	-2.97	-0.65	0.18	0.21	-0.75	78
Crudeoil	0.25	0.07	0.71	0.68	-1.07	95
Gold	-6.01	-1.01	0.44	0.44	0.02	108
Gold Guinea	-7.68	-1.51	0.12	0.14	2.26	56
Gold Mini	-4.11	-0.80	0.77	0.89	-0.33	108
Guargum	1.92	0.28	-1.46	-0.65	-2.42	40
Guarseed	7.05*	1.91	2.72	1.63	3.07	85
Kapas	5.33	0.95	1.34	1.49	-0.11	90
KapasiaKhalli	-1.25	-0.29	0.97	1.16	-0.96	97
Lead	4.17	0.80	-0.50	-0.33	-0.45	81
Lead Mini	-9.19	-0.69	1.28	0.78	-1.79	31
Maize	0.06	0.01	1.51	1.45	-1.75	59
Mentha Oil	0.02	0.00	0.86	0.75	-1.10	93
Naturalgas	1.34	0.11	-0.75	-0.47	-1.30	78
Nickel	3.13	0.78	0.32	0.30	-0.41	98
Pepper	-10.05	-0.84	3.00	1.35	-0.76	40
Potato	-1.25	-0.12	2.29	0.95	-1.49	68
Potato (Tarkeshwar)	-18.86	-1.26	-3.31	-0.40	1.78	34
Red Chilli	2.66	0.28	0.00	0.00	-3.28	30
Refinde Soy Oil	0.58	0.13	1.06	1.59	-1.24	81
Rubber	4.09	1.17	0.78	0.54	0.58	66
Silver	-2.11	-0.44	1.09	1.09	-0.76	108
Silver Mini	4.58	0.73	2.22	1.46	-0.44	107
Soyabean	1.75	0.24	0.85	0.44	-3.14	32
Steel Flat	-26.17***	-2.92	4.20***	2.78	20.00	31
Tin	2.85	0.50	1.26	0.61	-1.29	60
Turmeric	0.35**	2.07	5.87**	2.60	7.46	42
Wheat	1.28	0.32	1.45	1.44	-2.18	43
Zinc	-0.38	-0.09	0.63	0.60	-1.24	82
Zinc Mini	-4.77	-0.25	0.94	0.90	-3.12	32

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-Beta= consumption beta.obs=number of observations.

Table 3.2C: Time Series-Estimated Consumption Beta - NCDEX Exchange

Commodity	C-Beta	t-stat	Cons	t-stat	R^2	Obs
Aluminium	9.99	1.40	-2.45	-1.05	3.04	32
Barley	1.49	0.40	0.83	0.92	-1.19	73
Brent Crude Oil	1.22	0.32	0.72	0.67	-1.08	85
Castor Seed (Disa)	-13.75	-1.64	1.60	1.59	4.44	37
Castor Seed	4.79	0.25	0.96	0.35	-2.23	44
Chana (Delhi)	-0.14	-0.02	0.94	0.84	-1.04	98
Chilli (Guntur)	4.27	0.51	0.42	0.20	-1.04	73
Cotton Seed Oilcake(Akola)	-0.46	-0.02	1.61	1.02	-3.33	32
Copper	7.11	0.65	-0.34	-0.33	-1.51	40
Indian 31 Mm Cotton	-11.01	-0.90	2.36	1.22	-0.79	30
Medium Staple Cotton	-15.19	-0.66	3.54	0.83	-2.16	30
Crude Palm Oil (Kandla)	16.81**	2.08	0.58	0.68	4.74	68
Light Sweet Crude Oil	1.03	0.33	0.16	0.17	-1.41	65
Cashew (Kollam)	-8.82	-0.89	1.37	1.54	-0.68	31
Coriander (Kota)	1.37	0.17	2.84	1.24	-1.90	53
Furnaceoil	-8.38	-0.58	4.48	0.92	-2.73	30
Guar Gum	-14.87	-0.89	7.51**	2.04	-0.30	68
Guarseed	-31.03*	-1.97	9.08***	3.03	3.96	71
Gold Kg (Mumbai)	-5.74	-0.25	1.36	0.51	-2.76	36
Gur (Muzaffar Nagar)	-5.08	-0.81	0.64	0.64	-0.55	63
Jeera	-1.49	-0.25	1.06	1.03	-1.01	95
Raw Jute (Kolkata)	2.96	0.38	1.61	1.03	-2.18	41
Kapas	6.65	1.09	-0.41	-0.25	0.25	77
Maize (Nizamabad)	0.91	0.15	1.04	0.95	-2.33	44
MasoorGraing Bold	-7.67	-0.32	3.50	0.75	-3.73	30
Mentha Oil (Chandausi)	3.19	0.13	0.36	0.08	-3.93	30
Nickel	4.85	0.48	-1.99	-0.36	-3.33	30
Potato	-8.14	-1.07	4.42	1.10	0.59	30
Pepper (Kochi)	2.69	0.41	2.07	1.42	-1.00	85

Note: Robust z-statistics in brackets. ***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-Beta= consumption beta.obs=number of observations

Table 3.2D: Time Series-Estimated Consumption Beta - NCDEX Exchange (contd…)

Commodity	C-Beta	t-stat	Constant	t-stat	R^2	Obs
RBD Palm Olein (Kakinada)	24.11**	2.06	0.19	0.20	5.98	52
Rubber New (Kochi)	9.90***	2.96	-2.72	-1.98	12.98	53
R M Oil (Sri Ganga Nagar)	15.31	0.77	1.37	0.85	-1.57	30
Mustard seed (Jaipur)	-18.95	-0.75	-1.43	-0.57	-1.77	30
Soymeal (Indore)	1.90	1.37	3.81**	2.15	1.30	68
Yellow Soybean Meal	-23.58	-1.37	0.67	0.36	2.62	34
Shankar Kapas (Rajkot)	-1.01	-0.10	1.25	0.77	-2.35	44
Silver (Ahmedabad)	12.92	0.98	-2.67	-1.32	-0.13	30
Silver (Delhi)	28.46**	2.27	2.85*	1.82	11.84	32
Steel Long	5.10*	1.70	0.11	0.19	3.78	49
Sugar M Grade (Kolhapur)	-0.83	-0.18	0.63	0.66	-2.11	48
Soy Bean (Indore)	-0.30	-0.06	1.27	1.51	-0.94	108
Refined Soy Oil (Indore)	2.09	0.49	0.74	1.21	-0.77	101
Turmeric (Nizamabad)	-0.52	-0.08	2.33	1.61	-0.99	102
Wheat (Delhi)	1.09	0.22	1.28	1.45	-1.94	51
Zinc	-3.62	-0.29	2.13	0.32	-3.97	30

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% level. C-Beta= consumption beta; obs=number of observations.

3.3.3: Which Beta is More Related to Returns?

In this section, we estimate the market and consumption betas for commodity futures contracts which traded on the MCX and NCDEX bourses. The regression results in table 3.3A include the consumption and market beta together. The exchange wise cross section regression result of the combined exchanges (MCX and NCDEX) supports the market CAPM and consumption CAPM. The coefficient on the market beta is far larger than the coefficient on the consumption beta and it's almost double. The market beta rewards systematic risk with higher returns compared to the consumption beta. However, in the Indian commodity futures markets over the sample period

(January 2004 to December 2014) the relevant measure of systematic risk appears to be both the market beta as well as the consumption beta.

On the other hand, exchanges wise analysis indicates that in the case of NCDEX exchange, neither the market beta nor the consumption betas are significant. However, both the market and consumption beta coefficients are positive. In the case of the MCX exchange, the market beta coefficient is positive but not statistically significant. On the contrary, the consumption beta is positive and statistically also significant. The consumption beta rewards the systematic risk with higher returns and the relevant measure of systematic risk appears to be only the consumption beta rather than the market and consumption betas taken together.

On the whole, the exchange wise cross section analysis in Indian commodity futures markets during January 2004 to December 2014 indicates that there exists a positive risk premium and it is well explained by the both the traditional CAPM as well as the consumption based CAPM models. Though both the market beta and consumption betas are relevant measures of systematic risk during the sample period, the market beta rewards systematic risk with higher returns compared to the consumption beta at the aggregate level. But at the exchange level it is the consumption beta that rewards systematic risk with higher returns compared to the market beta.

Table 3.3A: Exchange Wise Cross Section - Estimated Consumption and Market Beta

	Market Beta		Consumption Beta		Constant		R^2
Futures	0.44***	[3.91]	0.28***	[8.51]	1.23***	[9.68]	0.36
MCX	0.41	[1.25]	0.24***	[5.75]	1.16***	[2.80]	0.52
NCDEX	0.39	[0.43]	0.27	[0.22]	1.37***	[3.30]	0.20

Note: Robust z-statistics in brackets. ***, **, * represents statistical significance at the 1%,5% and 10% levels; MCX stands for Multi Commodity Exchange of India Ltd; NCDEX stands for National Commodity & Derivatives Exchange Limited ; Futures means that commodities futures contracts should be unique to either of the exchanges.

Exchange (MCX and NCDEX) level time series properties of the commodity futures contract wise consumption beta and market beta analysis from tables 3.3B, 3.3C, 3.3D and 3.3E indicate that one consumption beta and five market betas out of thirty five commodity futures betas are significant on the MCX exchange and seven consumption and seven market betas out of forty five commodity futures betas are significant on the NCDEX exchange. Among the statistically significant commodity futures on the MCX, Crude Oil is negatively related to its consumption

beta and this beta is -8.22 percent. On the other hand, Crude oil, Guar gum, Nickel and Tin are positively related to its market beta and Steel Flat is negatively related to its market beta. These positive betas range from 0.48 percent to 10.97 percent and the statistically significant positive average beta turns out to be 6.87 percent, whereas the negative beta turns out to be -23.86 percent.

Contrary to the MCX exchange, on the NCDEX exchange, among the seven statistically significant beta coefficients Aluminium, RBD Palmolein (Kakinada), Rubber New (Kochi) and Silver (Delhi) are positively related to its consumption beta and Brent Crude Oil, Light Sweet Crude Oil, Guar seed are negatively related to consumption beta. Similarly Brent Crude Oil, Light Sweet Crude Oil, Sugar M Grade (Kolhapur) are positively related to its market beta and Castor Seed, Castor Seed (Disa), Indian 31 MM Cotton and Mentha Oil (Chandausi) are negatively related to its market beta. The positive statistically significant consumption betas range from 10.56 percent to 37.12 percent and similarly the positive market betas range from 9.30 percent to 14.76 percent. On the other hand, the negative statistically significant consumption betas range from -32.40 to -8.82 percent and similarly the negative statistically significant market betas range from -37.78 to -8.96 percent.

The average positive consumption betas on the NCDEX turn out to be 24.83 percent compared to the average market beta of 11.57 percent. On the other hand, the negative average consumption beta turns out to be -17.71 percent compare to the negative average market beta of -30.27 percent. Similarly, on the MCX, there are no statistically positive consumption betas and the positive average market beta turns out to be 6.87 percent compared to the negative average market beta of -23.86 percent.

Through the exchange wise cross section as well as the exchange wise individual commodity wise time series analysis we can conclude that in the Indian commodity futures markets over the period from January 2004 to December 2014, it is the market beta which is the more relevant measure of risk. However, the consumption beta is also a relevant measure of risk, but regardless of whether it is the exchange wise cross section analysis or the individual commodity wise analysis, the market beta dominates the consumption beta during the sample period.

Table 3.3B: Time Series-Estimated Consumption and Market Beta - MCX Exchange

Commodity	C-Beta	M-Beta	Constant	R^2	Obs
Aluminium	5.26 (1.02)	-3.32 (-0.75)	-0.21 (-0.20)	-0.87	85
Brent Crude Oil	3.87 (1.44)	3.85 (1.17)	0.50 (0.33)	5.13	74
Cardamom	-5.81 (-1.29)	-7.45 (-1.27)	2.69 (1.26)	0.68	83
Carbon (CFI)	-3.52 (-0.76)	11.11 (1.52)	-4.43 (-1.74)	0.94	35
Copper	2.24 (0.47)	1.57 (0.44)	0.26 (0.25)	-1.40	95
CPO	-5.95 (-1.20)	3.45 (1.46)	0.50 (0.58)	0.74	78
Crudeoil	-8.22* (-1.68)	8.06** (2.47)	1.43 (1.35)	4.19	95
Gold	-2.82 (-0.41)	2.18 (0.90)	1.10 (0.89)	-0.15	108
Gold Guinea	-3.84 (-0.57)	3.98 (0.87)	1.25 (0.80)	1.83	56
Gold Mini	-2.17 (-0.41)	3.37 (1.31)	1.40 (1.42)	0.35	108
Guargum	-3.70 (-0.51)	0.48* (1.97)	-1.49 (-0.69)	4.83	40
Guarseed	5.16 (1.28)	-3.38 (-1.15)	2.78 (1.67)	3.44	85
Kapas	3.26 (0.54)	4.80 (0.97)	1.26 (1.40)	-0.18	90
KapasiaKhalli	-1.32 (-0.31)	-1.47 (-0.38)	1.00 (1.19)	-1.88	97
Lead	4.52 (0.76)	-0.67 (-0.13)	-0.37 (-0.2)	-1.72	81
Lead Mini	-1.07 (-0.07)	9.58 (1.02)	-0.41 (-0.17)	-1.61	31
Maize	1.94 (0.27)	-5.96 (-1.04)	1.66 (1.58)	-1.60	59
Mentha Oil	-4.00 (-0.68)	-6.84 (-1.08)	1.91 (1.27)	-0.92	93
Naturalgas	1.99 (0.16)	-1.01 (-0.26)	-0.95 (-0.53)	-2.56	78
Nickel	2.90 (0.73)	7.97* (1.69)	-2.56 (-1.27)	1.50	98

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-beta= consumption beta, M-beta= market beta. Obs=number of observations.

Table 3.3C: Time Series-Estimated Consumption and Market Beta - MCX Exchange (contd…)

Commodity	C-Beta	M-Beta	Constant	R^2	Obs
Pepper	-8.43 (-0.67)	-10.3 (-0.51)	5.82 (0.97)	-2.77	40
Potato	-5.47 (-0.49)	4.77 (0.97)	-0.24 (-0.07)	-1.60	68
Potato (Tarkeshwar)	-29.98 (-1.18)	4.11 (0.55)	-5.20 (-0.58)	-0.42	34
Red Chilli	-2.91 (-0.24)	-1.67 (-0.73)	1.55 (0.53)	-5.02	30
Refinde Soy Oil	1.53 (0.32)	3.27 (0.57)	1.05 (1.57)	-2.12	81
Rubber	4.41 (1.19)	-2.08 (-0.26)	0.93 (0.59)	-0.89	66
Silver	-1.30 (-0.26)	1.97 (0.55)	0.62 (0.48)	-1.42	108
Silver Mini	5.58 (0.87)	2.26 (0.75)	1.84 (1.14)	-0.85	107
Soyabean	3.21 (0.41)	8.31 (0.7)	3.71 (0.82)	-4.93	32
Steel Flat	-12.88 (-1.30)	-23.86** (-2.46)	1.76 (1.03)	31.84	31
Tin	-0.37 (-0.06)	10.97* (1.72)	-0.43 (-0.19)	2.05	60
Turmeric	0.11 (0.36)	3.71 (0.95)	6.21 (2.72)	7.23	42
Wheat	2.17 (0.46)	1.42 (0.37)	1.61 (1.46)	-4.38	43
Zinc	-4.44 (-0.86)	7.75 (1.33)	-0.42 (-0.32)	-0.27	82
Zinc Mini	-4.39 (-0.23)	4.03 (0.62)	0.51 (0.4)	-5.26	32

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-beta= consumption beta, M-beta= market beta. Obs=number of observations.

Table 3.3D: Time Series-Estimated Consumption and Market Beta- NCDEX Exchange

Commodity	C-Beta	M-Beta	Constant	R^2	Obs
Aluminium	26.85*	-36.70	-7.38	5.09	32
	(1.80)	(-1.28)	(-1.65)		
Barley	0.43	-2.74	0.85	-2.32	73
	(0.10)	(-0.46)	(0.93)		
Brent Crude Oil	-11.91*	10.66**	2.67*	3.45	85
	(-1.69)	(2.21)	(1.94)		
Castor Seed (Disa)	1.98	-37.78*	2.75**	10.64	37
	(0.17)	(-1.85)	(2.38)		
Castor Seed	4.58	-8.96*	-2.09	2.23	44
	(0.24)	(-1.71)	(-0.65)		
Chana (Delhi)	-5.00	9.68	2.15	-0.22	98
	(-0.74)	(1.34)	(1.50)		
Chilli (Guntur)	4.84	-7.27	1.81	0.66	73
	(0.58)	(-1.49)	(0.80)		
Cotton Seed Oilcake(Akola)	1.58	-4.26	1.55	-6.72	32
	(0.07)	(-0.22)	(0.95)		
Copper	7.20	4.22	-0.93	-1.83	40
	(0.65)	(0.94)	(-0.77)		
Indian 31 Mm Cotton	42.89	-37.46**	-6.46	13.97	30
	(1.60)	(-2.22)	(-1.48)		
Medium Staple Cotton	-60.91	27.07	11.52	-0.80	30
	(-1.34)	(1.16)	(1.43)		
Crude Palm Oil (Kandla)	17.12	-0.67	0.54	3.34	68
	(2.07)	(-0.21)	(0.63)		
Light Sweet Crude Oil	-8.82**	9.30***	1.78*	13.41	65
	(-2.16)	(3.43)	(1.75)		
Cashew (Kollam)	19.27	-22.49	-1.82	1.68	31
	(0.81)	(-1.30)	(-0.70)		
Coriander (Kota)	-0.82	-5.07	4.27	-2.83	53
	(-0.10)	(-0.73)	(1.42)		
Furnaceoil	67.39	-42.92	-9.68	0.14	30
	(1.12)	(-1.30)	(-0.81)		
Guar Gum	-18.16	-9.93	7.42**	0.96	68
	(-1.09)	(-1.36)	(2.03)		
Guarseed	-32.40**	-4.80	9.16***	3.02	71
	(-2.03)	(-0.57)	(3.04)		
Gold Kg (Mumbai)	9.08	-10.04	3.54	-4.12	36
	(0.30)	(-0.75)	(0.89)		
Gur (Muzaffar Nagar)	-5.05	1.87	0.42	-2.11	63
	(-0.80)	(0.27)	(0.32)		
Jeera	-2.81	1.89	1.45	-1.86	95
	(-0.42)	(0.48)	(1.10)		
Raw Jute (Kolkata)	-1.14	15.63	-0.49	-1.61	41
	(-0.13)	(1.10)	(-0.20)		

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-beta= consumption beta, M-beta= market beta. Obs=number of observations.

Table 3.3E: Time Series-Estimated Consumption and Market Beta- NCDEX Exchange (contd…)

Commodity	C-Beta	M-Beta	Constant	R^2	Obs
Kapas	10.15 (1.56)	4.50 (1.43)	-0.52 (-0.32)	1.61	77
Maize (Nizamabad)	-1.27 (-0.19)	-8.58 (-0.94)	1.26 (1.13)	-2.63	44
MasoorGraing Bold	-12.96 (-0.34)	4.41 (0.18)	4.85 (0.55)	-8.09	30
Mentha Oil (Chandausi)	17.95 (0.73)	-36.89* (-1.73)	-3.57 (-0.75)	3.81	30
Nickel	-0.92 (-0.07)	8.09 (0.83)	-1.25 (-0.22)	-4.73	30
Potato	-7.98 (-1.03)	8.31 (0.55)	-3.35 (-0.23)	-2.37	30
Pepper (Kochi)	10.65 (1.14)	-10.02 (-1.19)	2.10 (1.45)	-0.50	85
RBD Palmolein (Kakinada)	24.79** (2.02)	1.34 (0.21)	0.11 (0.11)	4.15	52
Rubber New (Kochi)	10.56*** (2.68)	-1.34 (-0.33)	-3.10* (-1.71)	11.43	53
R M Oil (Sri Ganga Nagar)	9.91 (0.36)	6.10 (0.28)	1.45 (0.87)	-5.45	30
Mustard seed (Jaipur)	6.06 (0.80)	-15.73 (-1.07)	1.87 (1.58)	-1.46	60
Soymeal (Indore)	-3.14 (-0.87)	3.30 (1.51)	2.99 (1.62)	3.19	68
Yellow Soybean Meal	-24.09 (-1.33)	-1.40 (-0.11)	0.89 (0.32)	-0.48	34
Shankar Kapas (Rajkot)	-7.19 (-0.59)	6.28 (0.83)	3.96 (1.09)	-3.10	44
Silver (Ahmedabad)	14.90 (1.01)	1.63 (0.33)	-2.91 (-1.33)	-4.00	30
Silver (Delhi)	37.12** (2.73)	-11.97 (-1.48)	8.08** (2.10)	15.20	32
Steel Long	6.15 (1.19)	-1.08 (-0.25)	0.19 (0.27)	1.82	49
Sugar M Grade (Kolhapur)	-5.81 (-1.06)	14.76* (1.70)	0.59 (0.63)	1.96	48
Soy Bean (Indore)	-0.60 (-0.13)	2.97 (0.66)	1.24 (1.47)	-1.47	108
Refined Soy Oil (Indore)	2.14 (0.50)	0.73 (0.20)	0.75 (1.22)	-1.75	101
Turmeric (Nizamabad)	-1.10 (-0.16)	-1.70 (-0.45)	2.17 (1.45)	-1.80	102
Wheat (Delhi)	3.46 (0.59)	5.00 (0.81)	2.01 (1.59)	-2.65	51
Zinc	-3.98 (-0.31)	-4.03 (-0.2)	3.80 (0.36)	-8.49	30

Note: Robust z-statistics in brackets.***, **, * represents statistical significance at the 1%, 5% and 10% levels. C-beta= consumption beta, M-beta= market beta. Obs=number of observations.

3.4: Conclusion

Through the capital asset pricing model in the literature is well established that assets with higher betas (i.e. higher systematic risk) earn higher average returns compared to those with lower betas. Based on similar logic, in India we examine the exchange wise cross section as well as the time series properties of commodity futures contract's returns series to determine whether this positive relationship exists or not in the Indian commodity futures markets in the period during January 2004 to December 2014.

In terms of the market beta analysis, the cross section analysis indicates that there is a positive relationship between commodity futures contracts and its market beta in the case of combined exchanges unique commodity futures contracts. However, the MCX and NCDEX exchange level cross section betas are positive but not statistically significant. Similarly, the exchange wise individual commodity futures contracts time series analysis indicates that in the case of MCX, Brent Crude Oil, Crude oil, Guar gum, Nickel, Tin and Turmeric are positively related to its market beta and Guar seed and Steel Flat are negatively related to its market beta. On the other hand, in the case of NCDEX, Light Sweet Crude Oil, Soymeal (Indore) are positively related to its market beta and Castor Seed (Disa), Castor Seed, Indian 31 MM Cotton are negatively related to its market beta.

In terms of consumption beta analysis, the cross section analysis indicates that there is a positive relationship between commodity futures contracts and its consumption beta in the case of combined exchanges unique commodity futures contracts and MCX. However, the NCDEX exchange level cross section beta is also positive but not statistically significant. Similarly, the exchange wise individual commodity futures contracts time series analysis indicates that in the case of MCX, Brent Crude Oil, Guar seed and Turmeric are positively related to its consumption beta and Steel Flat is negatively related to its consumption beta. On the other hand, in the case of the NCDEX, Crude Palm Oil (Kandla), RBD Palm Olein (Kakinada), Rubber New (Kochi), Silver (Delhi), Steel Long are positively related to its consumption beta and Guar seed is negatively related to its consumption beta.

Similar to the market beta analysis, coincidentally in the case of consumption beta analysis also we have only ten percent of the individual commodity (eighty individual commodity futures

contracts which includes MCX thirty five and NCDEX forty five) futures contracts which are positively related to its consumption beta but the MCX and combined exchanges unique commodity futures contracts cross section consumption betas turned out to be 0.27 percent and 0.33 per cent, which means there exists a positive risk premium in the Indian commodity futures markets over the sample period and it moves along with the general market and is only one third in size.

In terms of the consumption and market beta analysis, the cross section analysis indicates that there is a positive relationship between commodity futures contracts and its consumption as well as the market beta in the case of the combined exchanges unique commodity futures contracts and in the case of MCX futures contracts only the consumption beta is positively related but the not the market beta. However, once again the NCDEX exchange level cross section beta is also positive but not statistically significant. Similarly, the exchange wise individual commodity futures contracts time series analysis indicates that in the case of MCX, Crude Oil is negatively related to its consumption beta. On the contrary, Crude oil, Guar gum, Nickel and Tin are positively related to its market beta and Steel Flat is negatively related to its market beta. On the other hand, Aluminium, RBD Palmolein (Kakinada), Rubber New (Kochi) and Silver (Delhi) are positively related to its consumption beta and Brent Crude Oil, Light Sweet Crude Oil, Guar seed are negatively related to consumption beta. Similarly Brent Crude Oil, Light Sweet Crude Oil, Sugar M Grade (Kolhapur) are positively related to its market beta and Castor Seed, Castor Seed (Disa), Indian 31MM Cotton and Mentha Oil (Chandausi) are negatively related to market beta.

In the combined analysis of consumption and market beta analysis, we find that only five percent (four out of eighty commodity futures contracts of MCX and NCDEX) of the commodity futures contracts are positively related to its consumption beta and approximately nine percent (seven out of eighty commodity futures contracts of MCX and NCDEX) of the commodity futures contracts are positively related to its market beta. The exchange level combined exchanges unique commodity futures contracts cross section consumption beta turned out to be 0.28 percent and market beta turned out to be 0.44 percent. Similarly, the MCX exchange cross section consumption beta turned out to be 0.24 percent. It is also evident from the joint analysis of consumption and market betas that there exists a positive risk premium in the Indian commodity

futures markets over the sample period and it moves along with the general market but is only half in the size in terms of market beta and one third in terms of consumption beta.

On the whole exchange wise cross section betas are positive and they turn out to be on an average approximately 0.5 percent in terms of market beta and 0.3 percent in terms of the consumption beta. Hence we can say that in the Indian commodity futures markets there exists a positive risk premium during the sample period from January 2004 to December 2014.

The following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation are such as Brent Crude Oil, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapas, Lead, Lead Mini, Nickel, Refined Soy Oil, Rubber, Silver, Silver Mini, Soyabean, Tin, Turmeric, Wheat, Zinc and Zinc Mini possess positively market beta coefficients. Similarly, the NCDEX's commodities such as Barley, Brent Crude Oil, Castor Seed, Chilli (Guntur), Copper, Light Sweet Crude Oil, Coriander(Kota), Raw Jute(Kolkata), Kapas, Nickel, Pepper (Kochi), R M Oil (Sri Ganga Nagar, Soymeal (Indore), Silver (Ahemadabad), Refined Soyoil (Indore), Wheat(Delhi) also possess positive market beta coefficients. These commodities on an average are very risky given their market beta levels. These commodities offers much higher returns whenever market returns are increasing and offers lower returns whenever the market is in the downside. These commodities are very well suited for the risk lovers.

Similarly, the following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation are such as Almond, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapaskhali, Maize, Menthaoil, Pepper, Thermal Coal and Urad possess negative market beta coefficients. Similarly, NCDEX's commodities such as Castor disa, Chana, Cotton Seed Oilcake, Cotton Seed Oilcake Akola, Cotton Seed Oilcake Kadi, Copper since 2010, Furnace oil, Guar Gum , Gold Pure Mumbai Kg, Groundnut Expeller Oil, Groundnut(in shell), Gold, Gold 100 Grams , Gur, Gur MZFNR, Jeera, Jute Sacking, Yellow/Red Maize, Masoor Bold, Polypropylene, PVC, PVC - Mumbai, Rape Mustard Seed, RM Seed, RMseed oilcake, Soyameal Export, Sesame Seed, Shankar Kapas(Rajkot), Silver5Kg Ahmd before 2008, Soya Bean, Turmeric, Yellow Peas, Zinc possess negative market beta coefficients. These commodities serve as insurance against a drop in the market returns. If someone adds these negative market beta commodities to their portfolio reduces the overall portfolio risk.

CHAPTER 4

COMMODITY FUTURES HEDGING AGAINST INFLATION IN INDIA

4.1: Introduction

Inflation has been a dominant feature in the economy of developing and developed countries over the past few decades. Though the short term effects of price heating may be small but long term price heating could be substantially erosive on real asset returns. It has become a problem for individual investors who are attempting to retain the real value and returns on their accumulated earnings. There exists a huge literature in financial economics on the relationship between asset prices and inflation. Several empirical studies (Lintner, 1975; Bodie, 1976; (Nelson, 1976; Fama and Schwert, 1977; Jaffe and Mandelkar, 1979; Fama, 1981 and 1982; Geske and Roll, 1983; Wahlroos and Berglund, 1986; Chatrath et al., 1997; Adrangi et al., 2003; and Al-Rjoub, 2005) have shown that there exists a negative relationship between stock returns and expected and unexpected inflation during the rapid inflation years of the 1970s in the United States. On the other hand, some studies (Pearce and Roley, 1985; Hardouvelis, 1987; McQueen and Roley, 1993; Caporale and Jung, 1997) find no significant relationship between stock returns and inflation.

Whenever there is a rise in inflation, commodity prices tend to rise along with inflation. In a rising inflationary environment, prices of goods and services will also increase, so commodity prices tend to be correlated with inflation. This may not be true in the short term but surely it holds in the long run. Therefore, investors who are worried about inflationary effects will prefer to invest in assets that provide some protection against increases in the price level. So inflation hedging has become particularly relevant in the recent past given the rapid general price rise. A vast amount of literature has examined inflation hedging effectiveness using various classes of assets, such as equities, bonds, real estate and commodities.

The empirical research (Chua and Woodward, 1982; Gorton and Rouwenhorst, 2006; Erb and Harvey, 2006; Worthington and Pahlavani, 2007; Hoevenars et al, 2008; Bekaert and Wang, 2010; and Spierdik and Umar, 2013) has documented the positive hedging ability of

commodities and commodity futures with inflation. Among these studies, few focused on commodities or commodity futures indices, and others focused on a single commodity such as gold and silver. Erb and Harvey (2006) and Spierdik and Umar (2014) are notable exceptions. These studies examined commodity futures in different markets over different investment time horizons.

In this chapter, we examine the following questions. 1) The extent to which commodity futures markets are effective in hedging against inflation and its components (expected and unexpected)? 2) Is there an exchange specific bias in hedging against inflation and its components? 3) Does it matter whether commodity futures contracts still exist (continue to trade) or not? and 4) Is there any sector specific bias in hedging against inflation and its components in India over the period from January 2004 to December 2014. Since in the second chapter it has been established that commodity futures are the next best alternative to equities in India for investment and in chapter three it also has been proven that there is a trade-off between risk and return, hence it becomes imperative to examine the four questions, mentioned above during the period January 2004 to December 2014 in India. The rest of the chapter is organized as follows: section 2 provides description of the data and methodology. Section 3 reports the empirical results and discussion and finally section 4 concludes.

4.2: Data and Methodology

This study utilizes monthly commodity futures contracts data drawn from the National Commodity and Derivatives Exchange (NCDEX) and Multi Commodity Exchange (MCX). The reason for focusing only on these two exchanges is that they constitute about 96.19 [9]percent of the total commodity futures market in India. The sample period starts from January 2004 to December 2014. We have applied a filter in selecting the sample that if a commodity futures contract trades for at least thirty (30) months then that commodity futures contract is included in the sample otherwise it is excluded. After applying the criterion, our sample consists of 54 commodity futures contracts from the MCX and 69 commodity futures contracts from the NCDEX. All these commodity futures contracts are classified according to their nature such as agricultural products, energy, environmental, precious and non-precious metals. The rate of inflation has been calculated using the monthly Whole Sale Price (WPI) index published by the

[9]Forward Market Commission Annual Report (2013-14).

Reserve Bank of India (RBI). Similarly, we also used the three month treasury bills as a proxy for expected inflation and data for the same is drawn from Bloomberg. Unexpected inflation has been defined as expected inflation minus realized (actual) inflation.

In order to quantify the inflation hedging value of each commodity of the Indian Commodity futures contracts, the following simple regression model is employed:

$$R_t = \omega + \beta I_t + \varepsilon_t \qquad (4.1)$$

Where R_t represents the monthly commodity returns, I_t is the inflation rate. The null hypothesis is that the Indian Commodity futures are not hedgeable against inflation during the sample period. If the commodity provides some protection against inflation for the savers, one would expect the estimated slope (β) coefficient in the above equation (4.1) to be positive and statistically significant; i.e. increases inflation in India lead to contemporaneous increase in the return on commodity futures contracts. A statistically significant value of the βcoefficient between 0 and 1 would indicate that a particular commodity futures contract is only a partial hedge against domestic inflation, whereas values of the estimated β greater than or equal to 1 would indicate that a particular commodity futures contract is a complete hedge. Following the literature, especially Jaffe and Mandelker (1976), Fama and Schwert (1978) and Chua and Woodward (1982), we want make equation (4.1) (here onwards equation 4.1 is considered as model 1) more meaningful, hence we decided to consider the extent to which each Indian commodity futures contract has been a hedge against both expected and unexpected inflation.

In an attempt therefore to examine the extent to which each commodity futures contract has been an effective hedge against expected and unexpected inflation in India the following model is employed:

$$R_t = \omega + \gamma I_t^e + \delta I_t^u + \varepsilon_t \qquad (4.2)$$

Where I_t^e refers to the expected inflation rate at time period t and I_t^u refers to the unexpected component of the actual inflation rate at time period "t". The null hypothesis is that the Indian Commodity futures are not hedgeable against expected and unexpected inflation during the sample period. Here onwards equation (4.2) is considered as model 2.

4.2: Results and Discussion

Table 4.1A: Estimated Regression Coefficients of Model 1-MCX

Commodity Name	Sector	Inflation(β)	t-stat	Constant	t-stat	Obs	R^2
Badam	Agri	0.35	[0.19]	0.00	[0.24]	37	0.00
Aluminium	Non-Precious	2.14*	[1.99]	-0.01	[-1.04]	46	0.10
Aluminium Mini	Non-Precious	3.19***	[3.81]	-0.01*	[-1.75]	108	0.14
ArecanutJahaji	Agri	-0.61	[-0.58]	0.00	[-0.12]	38	0.01
ATF	Energy	4.46**	[2.63]	-0.02	[-1.09]	46	0.15
Barley	Agri	1.81	[0.68]	0.00	[0.20]	30	0.02
Brent Crude Oil	Energy	5.78***	[2.99]	-0.01	[-0.77]	54	0.11
Cardamom	Agri	0.46	[0.29]	0.02	[1.26]	106	0.00
CER	Environ	4.15*	[1.71]	-0.04*	[-1.97]	40	0.09
CFI	Environ	4.86**	[2.21]	-0.04	[-1.58]	58	0.10
Chana	Agri	1.75	[0.72]	0.01	[0.38]	46	0.01
Chana-Delhi	Agri	-1.21	[-0.51]	0.03	[1.37]	41	0.01
Copper	Non-Precious	3.82***	[3.22]	-0.01	[-0.77]	116	0.12
Copper Mini	Non-Precious	2.41*	[1.84]	-0.01	[-1.10]	36	0.15
Coriander	Agri	8.40***	[4.89]	-0.05***	[-3.90]	52	0.26
Cotton	Agri	0.92	[0.54]	-0.01	[-0.49]	38	0.01
CPO	Agri	1.08	[1.07]	0.00	[-0.41]	78	0.01
Crudeoil	Energy	3.82***	[3.03]	-0.01	[-1.01]	118	0.10
Flake Menthol	Agri	2.02	[0.39]	0.02	[0.55]	30	0.01
Gasoline	Energy	1.99	[0.84]	0.00	[0.12]	34	0.02
Gold	Precious	0.41	[0.51]	0.01*	[1.92]	131	0.00
Gold Guinea	Precious	0.50	[0.53]	0.01	[1.22]	79	0.00
Gold Mini	Precious	0.34	[0.43]	0.01**	[1.99]	131	0.00
Gold Petal	Precious	2.50*	[1.75]	-0.01	[-0.71]	44	0.09
Gold Petal-Delhi	Precious	2.52*	[1.96]	-0.01	[-1.62]	37	0.14
Guar Seed	Agri	0.34	[0.22]	0.04**	[2.13]	85	0.00
Heatingoil	Energy	3.31***	[2.71]	0.00	[-0.11]	40	0.10
Jeera	Agri	1.23	[0.99]	0.00	[0.38]	52	0.01
Kapas	Agri	-1.58	[-0.80]	0.02	[1.46]	65	0.01
Kapaskhali	Agri	0.78	[0.87]	0.01	[1.00]	123	0.01
Lead	Non-Precious	2.61*	[1.71]	-0.01	[-0.53]	90	0.04
Lead Mini	Non-Precious	2.21	[1.52]	0.00	[-0.15]	54	0.05

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.1B: Estimated Regression Coefficients of Model 1-MCX (contd…)

Commodity Name	Sector	Inflation(β)	t-stat	Constant	t-stat	Obs	R^2
Maize	Agri	3.42*	[1.86]	-0.01	[-0.48]	35	0.06
Menthaoil	Agri	1.10	[0.68]	0.01	[0.62]	116	0.00
Natural Gas	Energy	1.58	[1.01]	-0.01	[-0.38]	101	0.01
Nickel	Non-Precious	1.26	[1.00]	0.00	[-0.08]	98	0.01
Nickel Mini	Non-Precious	1.61	[1.29]	-0.01	[-0.45]	36	0.04
Pepper	Agri	1.19	[0.79]	0.01	[0.49]	58	0.01
Platinum	Precious	2.94	[0.75]	-0.03	[-0.72]	44	0.02
Potato	Agri	-1.53	[-0.87]	0.04*	[1.85]	68	0.00
Refined Soyoil	Agri	3.41**	[2.28]	-0.01	[-1.16]	54	0.14
Rubber	Agri	6.84**	[2.41]	-0.02	[-1.00]	42	0.27
Silver	Precious	1.48	[1.24]	0.01	[0.77]	131	0.02
Silver Mini	Precious	1.97	[1.52]	0.00	[0.49]	130	0.02
Silver Micro	Precious	6.18**	[2.32]	-0.03**	[-2.17]	46	0.17
Soyabean	Agri	1.08	[0.41]	0.00	[0.19]	32	0.01
Sugar Mini-Kolkata	Agri	1.37	[1.51]	-0.01	[-0.67]	32	0.03
Thermal Coal	Energy	5.44***	[3.02]	-0.03	[-1.66]	34	0.19
Tin	Non-Precious	5.50***	[4.53]	-0.02	[-1.47]	59	0.24
Turmeric	Agri	4.02**	[2.15]	0.03	[1.27]	42	0.05
Urad	Agri	2.38	[0.63]	0.03	[0.97]	30	0.01
Wheat	Agri	-0.59	[-0.50]	0.02	[1.46]	43	0.00
Zinc	Non-Precious	1.35	[1.23]	0.00	[-0.33]	105	0.01
Zinc Mini	Non-Precious	1.83	[1.33]	0.00	[0.12]	55	0.04

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;.

Table 4.2A: Estimated Regression Coefficients of Model 1-NCDEX

Commodity Name	Sector	Inflation(β)	t-stat	Constant	t-stat	Obs	R^2
Aluminium	NonPrecious	6.32***	[5.33]	-0.03***	[3.10]	37	0.41
Barley	Agri	0.78	[0.64]	0.01	[0.72]	95	0.00
Brent Crude Oil	Energy	5.74***	[4.98]	-0.02*	[1.85]	110	0.25
CastorDisa	Agri	2.72**	[2.39]	0.00	[0.52]	60	0.12
Castor Seed	Agri	0.02	[0.01]	0.01	[0.79]	66	0.00
Chana	Agri	0.33	[0.21]	0.00	[0.29]	72	0.00
Chilli LCA 334	Agri	2.51	[1.23]	0.00	[0.14]	96	0.02
Cotton Seed Oilcake	Agri	3.13**	[2.02]	-0.01	[0.58]	64	0.06
Cotton Seed Oilcake Akola	Agri	1.97	[1.59]	0.01	[0.80]	55	0.03
Cotton Seed Oilcake Kadi	Agri	2.86*	[1.92]	0.00	[0.01]	35	0.08
Copper before 2010	NonPrecious	6.79**	[2.59]	-0.02	[1.08]	35	0.30
Copper since 2010	NonPrecious	2.10**	[2.54]	0.00	[0.54]	62	0.06
Indian 31 mm cotton	Agri	4.04***	[4.33]	-0.01	[1.57]	48	0.34
Medium Staple Cotton	Agri	3.19***	[4.64]	0.00	[0.44]	51	0.19
Crude palm oil	Agri	3.16***	[2.67]	-0.01	[1.49]	70	0.10
Crude Oil	Energy	6.51***	[5.79]	-0.03**	[2.14]	87	0.30
Cashew	Agri	1.87**	[2.14]	-0.01	[0.91]	55	0.12
Dhaniya	Agri	1.13	[0.64]	0.01	[0.47]	75	0.00
Furnaceoil	Energy	5.93**	[2.48]	-0.01	[0.62]	49	0.20
Guar Gum	Agri	2.68*	[1.86]	0.02	[1.46]	91	0.02
Guar Seed	Agri	1.80	[1.32]	0.03*	[1.82]	94	0.01
Gold Pure Mumbai Kg	Precious	0.54	[0.38]	0.02*	[1.69]	47	0.01
Groundnut Expeller Oil	Agri	1.44	[1.08]	0.00	[0.26]	46	0.03
Groundnut(in shell)	Agri	0.68	[0.70]	0.01	[0.86]	46	0.01
Gold	Precious	1.67*	[1.94]	0.00	[0.15]	48	0.04
Gold 100 Grams Ahmedabad	Precious	-1.73	[1.49]	0.03***	[2.69]	46	0.03

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.2B: Estimated Regression Coefficients of Model 1-NCDEX (contd…)

Commodity Name	Sector	Inflation(β)	t-stat	Constant	t-stat	Obs	R^2
Gur	Agri	1.96	[1.24]	-0.01	[0.41]	32	0.02
Gur Muzaffarnagar	Agri	1.21	[1.04]	0.01	[0.82]	85	0.01
Jeera	Agri	1.16	[1.22]	0.00	[0.13]	117	0.01
Jute Sacking	Agri	-0.79	[0.49]	0.02	[1.33]	30	0.01
Raw Jute	Agri	0.11	[0.10]	0.02	[1.11]	41	0.00
V 797 Kapas	Agri	2.57***	[2.78]	0.00	[0.13]	99	0.04
Linear LD Polyethylene	Energy	4.09*	[1.81]	-0.01	[0.41]	34	0.16
Maize	Agri	2.37	[1.26]	0.00	[0.12]	34	0.03
Yellow/Red Maize	Agri	1.59	[1.34]	0.00	[0.44]	67	0.03
RM seedoilcake	Agri	0.90	[1.06]	0.02*	[1.73]	46	0.02
Masoor Bold	Agri	4.52***	[2.73]	0.00	[0.16]	49	0.20
Menthaoil	Agri	0.93	[0.76]	0.01	[0.29]	50	0.00
Nickel	NonPrecious	3.37	[1.36]	-0.02	[0.94]	48	0.06
Potato	Agri	5.85	[0.71]	-0.02	[0.28]	32	0.02
Polypropylene	Energy	5.16**	[2.54]	-0.02	[0.72]	34	0.20
Black Pepper	Agri	2.85**	[2.26]	0.00	[0.30]	108	0.04
PVC	Energy	3.13**	[2.23]	-0.01	[0.77]	32	0.12
PVC – Mumbai	Energy	2.66	[1.23]	-0.01	[0.24]	34	0.08
RBD Palmolein	Agri	3.12**	[2.52]	-0.01	[1.29]	75	0.10
Rubber_New	Agri	1.95	[1.55]	-0.02*	[1.94]	35	0.05
Rubber RSS 4	Agri	2.70	[0.70]	0.01	[0.44]	42	0.01
RM Oil	Agri	3.20**	[2.21]	-0.01	[0.47]	50	0.16
RM Seed	Agri	0.94	[0.74]	0.01	[0.54]	48	0.01
Mustard Seed	Agri	3.86***	[2.98]	-0.01	[1.58]	83	0.19

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.2C: Estimated Regression Coefficients of Model 1-NCDEX (contd…)

Commodity Name	Sector	Inflation(β)	t-stat	Con	t-stat	Obs	R^2
Soymeal (Indore)	Agri	2.00	[1.23]	0.01	[0.71]	91	0.02
Soyameal Export	Agri	0.63	[0.37]	0.01	[0.56]	58	0.00
Sesame Seed	Agri	5.78	[1.33]	0.00	[-0.02]	44	0.11
ShankarKapas(Rajkot)	Agri	3.62***	[3.52]	-0.01	[-0.73]	53	0.22
Silver	Precious	4.32***	[3.24]	-0.02	[-1.34]	48	0.09
Silver 5Kgs Ahmd after2008	Precious	1.91	[0.73]	0.02	[0.65]	39	0.01
Silver 5 Kgs	Precious	1.79	[0.92]	0.00	[0.10]	34	0.04
Silver 5Kgs Ahmd before2008	Precious	2.11	[1.12]	0.01	[0.44]	55	0.03
Steel Long (BIS 2830)	NonPrecious	2.78*	[1.77]	-0.01	[-0.84]	75	0.09
Steel Long	NonPrecious	5.90***	[2.97]	-0.02	[-1.52]	44	0.32
Sugar (M Grade)	Agri	0.06	[0.05]	0.00	[-0.11]	45	0.00
Sugar (M Grade) Muzzafarnagar	Agri	-0.38	[-0.37]	0.00	[-0.35]	41	0.00
Sugar (M Grade) Kolkata	Agri	0.66	[0.39]	-0.01	[-0.60]	30	0.00
Soya Bean	Agri	1.22	[1.03]	0.00	[0.25]	130	0.01
Soy oil-refined	Agri	1.75**	[2.53]	-0.01	[-1.10]	130	0.05
Turmeric	Agri	3.05	[1.48]	0.00	[-0.03]	124	0.03
Wheat	Agri	-0.54	[-0.25]	0.01	[1.16]	49	0.00
Yellow Peas	Agri	3.15**	[2.51]	-0.01	[-0.40]	35	0.14
Zinc	NonPrecious	2.97	[1.30]	-0.01	[-0.64]	48	0.07

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Equation (4.1) assumes that if a particular commodity futures contract offers some protection against inflation, one would expect the estimated slope coefficient of the equation to be positive and statistically significant; that is, an increase in domestic inflation leads to contemporaneous increases in the returns on that particular commodity futures contract. A statistically significant value of β between 0 and 1 would indicate that a particular derivative contract (in this case the commodity futures contract) is only a partial hedge against domestic inflation, whereas values of estimated β greater than or equal to 1 would indicate that a particular commodity futures contract is a complete hedge. On the other hand, if they are negative and significant then there exists a negative relationship between the commodity futures and inflation components (expected and unexpected inflation).

From tables 4.1A and 4.1B it is evident that among all the commodity futures contracts which trade on the Multi Commodity Exchange (MCX), Aluminium, Aluminium Mini, ATF, Brent Crude Oil, CER, CFI, Copper, Copper Mini, Coriander, Crude oil, Gold Petal, Gold Petal-Delhi, Heating oil, Lead, Maize, Refined Soy oil, Rubber, Silver Micro, Thermal Coal, Tin and Turmeric are positive and statistically significant. These positive and statistically significant estimated β coefficients range from 2.14 to 8.40 and these coefficients are all above one. Hence, we can say that according to the estimated model (1), commodity futures contracts such as Aluminium (2.14), Aluminium Mini (3.19), ATF (4.46), Brent Crude Oil (5.78), CER (4.15), CFI (4.86), Copper (3.82), Copper Mini (2.41), Coriander (8.40), Crude oil (3.82), Gold Petal (2.50), Gold Petal-Delhi (2.52), Heating oil (3.31), Lead (2.61), Maize (3.42), Refined Soy oil (3.41), Rubber (6.84), Silver Micro (6.18), Thermal Coal (5.44), Tin (5.50) and Turmeric (4.02) provide a perfect hedge against inflation in India. 21 Out of 54 commodity futures which trade on the MCX can be successfully hedged against inflation. These perfectly hedgeable commodity futures do not belong to any specific sector. Rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. However, a majority of the hedgeable commodity futures belong to the agricultural sector. Out of these 21 perfectly hedgeable commodity futures contracts, only the following contracts - Aluminium, Aluminium Mini, Brent Crude,Copper, Copper Mini,Crude oil, Gold Petal, Gold Petal-Delhi, Lead and Silver contracts still continue to trade on the MCX and the rest are not trading anymore. This proves that it doesn't matter whether the contracts are still trading on the MCX exchange or not rather they are market (i.e. instrument) specific.

Similarly, tables 4.2A, 4.2B and 4.2C report that among all the commodity futures contracts which trade on the National Commodity and Derivative Exchange (NCDEX), Aluminium, Brent Crude Oil, Castor Disa, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper before 2010, Copper since 2010, Indian 31 mm cotton, Medium Staple Cotton, Crude palm oil, Crude Oil, Cashew, Furnace oil, Guar Gum, Gold, Kapas V 797, Linear LD Polyethylene, Masoor Bold, Polypropylene, Black Pepper, PVC, RBD Palmolein, Rape Mustard Oil, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830), Steel Long, Soy oil-refined and Yellow Peas are positive and statistically significant. These positive and statistically significant estimated β coefficients range from 1.67 to 6.79 and these coefficients are all above one. Hence, we can say that according to the estimated model 1, commodity futures contracts such as Aluminium (6.32), Brent Crude Oil (5.74), Castor Disa (2.72), Cotton Seed Oilcake (3.13), Cotton Seed Oilcake Kadi (2.86), Copper before 2010 (6.79), Copper since 2010 (2.10), Indian 31 mm cotton (4.04), Medium Staple Cotton (3.19), Crude palm oil (3.16), Crude Oil (6.51), Cashew (1.87), Furnace oil (5.93), Guar Gum (2.68), Gold (1.67), Kapas V797 (2.57), Linear LD Polyethylene (4.09), Masoor Bold (4.52), Polypropylene (5.16), Black Pepper (2.85), PVC (3.13), RBD Palmolein(3.12), Rape Mustard Oil (3.20), Mustard Seed (3.86), Shankar Kapas (Rajkot) (3.62), Silver (4.32), Steel Long (BIS 2830) (2.78), Steel Long (5.90), Soy oil-refined (1.75) and Yellow Peas (3.15) provide a perfect hedge against inflation in India over the period January 2004 to December 2014.

30 Out of 69 Commodity futures which trade on the NCDEX can be successfully hedged against inflation. Out of these 30 perfectly hedgeable commodity futures contracts, only the following contracts such as Brent Crude, Copper since 2010,Crude Oil, Gold, Kapas V797, RBD Palmolein, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830) and Soy oil-refined contracts are still continuing to trade on the NCDEX and the rest are not trading anymore. This proves that it doesn't matter whether the contracts are still trading on the NCDEX exchange or not, rather they are market (i.e. instrument) specific. Similar to the MCX, NCDEX's perfectly hedgeable commodity futures do not belong to any specific sector, rather they are spread across agriculture, environmental, energy, precious and non-precious metals sectors. However, once again a majority of the hedgeable commodity futures belong to the agricultural sector.

On the whole, irrespective of the exchange they are traded on, commodity futures contracts such as Aluminium, Brent Crude, Copper, Crude oil, Gold, Silver are perfectly hedgeable against inflation in India.

Table 4.3A: Estimated Regression Coefficients of Model 2-MCX

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Badam	Agri	0.88 [0.11]	0.36 [0.19]	0.00 [0.04]	37	0.00
Aluminium	NonPrecious	4.22 [0.44]	2.10* [1.98]	-0.02 [-0.35]	46	0.11
Aluminium Mini	NonPrecious	-1.66 [-0.36]	3.11*** [3.63]	0.02 [0.56]	108	0.15
ArecanutJahaji	Agri	17.56** [2.05]	-0.58 [-0.53]	-0.10** [-2.08]	38	0.08
ATF	Energy	-1.83 [-0.25]	4.29** [2.37]	0.01 [0.31]	46	0.17
Barley	Agri	-8.90 [-1.09]	2.09 [0.80]	0.07 [1.36]	30	0.06
Brent Crude Oil	Energy	-38.54 [-1.18]	6.03*** [2.83]	0.28 [1.24]	54	0.22
Cardamom	Agri	-8.78 [-1.15]	0.29 [0.18]	0.07 [1.59]	106	0.01
CER	Env	-11.40 [-1.12]	3.58 [1.51]	0.03 [0.55]	40	0.14
CFI	Env	-4.54 [-0.48]	4.76** [2.14]	0.01 [0.24]	58	0.11
Chana	Agri	0.76 [0.04]	1.78 [0.74]	0.01 [0.12]	46	0.01
Chana-Delhi	Agri	11.64 [1.57]	-1.28 [-0.56]	-0.03 [-0.88]	41	0.09
Copper	NonPrecious	-8.89* [-1.78]	3.65*** [3.00]	0.06** [2.26]	116	0.16
Copper Mini	NonPrecious	-0.43 [-0.04]	2.48* [1.84]	0.01 [0.14]	36	0.15
Coriander	Agri	19.14** [2.22]	8.68*** [5.13]	-0.11** [-2.67]	52	0.28
Cotton	Agri	-6.11 [-0.42]	1.10 [0.60]	0.04 [0.43]	38	0.02
CPO	Agri	-7.08 [-1.28]	0.88 [0.87]	0.04 [1.38]	78	0.04
Crudeoil	Energy	-7.04 [-1.23]	3.67*** [2.85]	0.05 [1.48]	118	0.12
Flake Menthol	Agri	-0.79 [-0.04]	2.09 [0.41]	0.04 [0.37]	30	0.01

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.3B: Estimated Regression Coefficients of Model 2-MCX

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Gasoline	Energy	7.99 [1.01]	2.04 [0.87]	-0.03 [-0.59]	34	0.04
Gold	Precious	-1.69 [-0.50]	0.38 [0.47]	0.02 [1.28]	131	0.01
Gold Guinea	Precious	-2.89 [-0.69]	0.42 [0.43]	0.03 [1.23]	79	0.01
Gold Mini	Precious	-1.35 [-0.38]	0.32 [0.40]	0.02 [1.11]	131	0.00
Gold Petal	Precious	4.15 [0.28]	2.46 [1.67]	-0.02 [-0.16]	44	0.09
Gold Petal-Delhi	Precious	5.61 [0.38]	2.44* [1.82]	-0.03 [-0.31]	37	0.15
Guar Seed	Agri	19.93 [1.36]	0.55 [0.35]	-0.06 [-0.90]	85	0.03
Heatingoil	Energy	2.44 [0.42]	3.32** [2.66]	0.00 [0.08]	40	0.10
Jeera	Agri	5.07 [0.54]	1.22 [0.97]	-0.02 [-0.32]	52	0.02
Kapas	Agri	-7.82 [-1.22]	-1.78 [-0.90]	0.06 [1.67]	65	0.02
Kapaskhali	Agri	0.72 [0.15]	0.78 [0.86]	0.01 [0.33]	123	0.01
Lead	NonPrecious	-5.97 [-0.96]	2.44 [1.56]	0.04 [1.15]	90	0.06
Lead Mini	NonPrecious	-16.57 [-1.54]	2.32 [1.51]	0.12* [1.70]	54	0.11
Maize	Agri	6.93 [0.87]	3.44* [1.88]	-0.03 [-0.65]	35	0.06
Menthaoil	Agri	-9.59 [-1.08]	0.96 [0.59]	0.07 [1.35]	116	0.02
Natural Gas	Energy	-1.63 [-0.15]	1.53 [0.95]	0.01 [0.18]	101	0.01
Nickel	NonPrecious	-10.44 [-1.44]	1.05 [0.83]	0.07 [1.45]	98	0.03
Nickel Mini	NonPrecious	5.95 [0.38]	1.50 [1.17]	-0.04 [-0.33]	36	0.04
Pepper	Agri	1.43 [0.12]	1.19 [0.78]	0.01 [0.11]	58	0.01
Platinum	Precious	-25.79* [-1.96]	1.80 [0.54]	0.11** [2.28]	44	0.11

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.3C: Estimated Regression Coefficients of Model 2-MCX (contd…)

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Potato	Agri	7.99 [0.66]	-1.39 [-0.79]	-0.01 [-0.18]	68	0.01
Refined Soyoil	Agri	5.99 [1.37]	3.45** [2.32]	-0.03 [-1.10]	54	0.15
Rubber	Agri	-8.30 [-1.25]	6.84** [2.48]	0.05 [1.17]	42	0.35
Silver	Precious	-6.93 [-1.19]	1.37 [1.11]	0.05* [1.72]	131	0.03
Silver Mini	Precious	-5.18 [-0.82]	1.88 [1.40]	0.04 [1.32]	130	0.04
Silver Micro	Precious	14.05 [0.55]	6.05** [2.23]	-0.08 [-0.48]	46	0.17
Soyabean	Agri	16.32 [1.56]	0.91 [0.39]	-0.07 [-1.27]	32	0.11
Sugar Mini-Kolkata	Agri	17.48 [1.46]	0.78 [0.85]	-0.11 [-1.42]	32	0.09
Thermal Coal	Energy	-2.09 [-0.31]	5.42*** [3.21]	0.01 [0.32]	34	0.23
Tin	NonPrecious	-3.24 [-0.56]	5.40*** [4.46]	0.03 [0.87]	59	0.27
Turmeric	Agri	-14.69 [-0.89]	3.44* [2.00]	0.12 [1.34]	42	0.08
Urad	Agri	-39.51 [-0.95]	3.14 [0.88]	0.22 [1.08]	30	0.04
Wheat	Agri	-2.69 [-0.39]	-0.66 [-0.52]	0.03 [0.71]	43	0.01
Zinc	NonPrecious	-5.56 [-0.98]	1.22 [1.09]	0.04 [1.07]	105	0.03
Zinc Mini	NonPrecious	0.94 [0.09]	1.83 [1.31]	0.01 [0.10]	55	0.04

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.4A: Estimated Regression Coefficients of Model 2-NCDEX

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Aluminium	NonPrecious	1.76 [0.26]	6.26*** [5.13]	-0.01 [-0.39]	37	0.42
Barley	Agri	-3.70 [-0.66]	0.69 [0.56]	0.03 [0.99]	95	0.01
Brent Crude Oil	Energy	-1.76 [-0.31]	5.63*** [4.86]	0.02 [0.63]	110	0.27
Castor Disa	Agri	13.20* [1.70]	2.74** [2.35]	-0.06 [-1.46]	60	0.15
Castor Seed	Agri	-5.43 [-0.88]	-0.18 [-0.10]	0.04 [1.29]	66	0.01
Chana	Agri	2.90 [0.38]	0.40 [0.23]	-0.01 [-0.26]	72	0.00
Chilli LCA 334	Agri	1.35 [0.18]	2.50 [1.21]	0.01 [0.20]	96	0.02
Cotton Seed Oilcake	Agri	4.40 [0.58]	3.16** [2.03]	-0.02 [-0.36]	64	0.06
Cotton Seed Oilcake Akola	Agri	-1.89 [-0.17]	1.90 [1.50]	0.03 [0.56]	55	0.03
Cotton Seed Oilcake Kadi	Agri	-1.91 [-0.12]	2.83* [1.88]	0.03 [0.30]	35	0.08
Copper before 2010	NonPrecious	-15.93* [-1.75]	6.26** [2.56]	0.09* [1.84]	35	0.40
Copper since 2010	NonPrecious	1.59 [0.28]	2.09** [2.39]	0.00 [-0.03]	62	0.06
Indian 31 mm cotton	Agri	7.04 [1.33]	4.09*** [4.18]	-0.03 [-1.00]	48	0.34
Medium Staple Cotton	Agri	1.99 [0.34]	3.17*** [4.56]	0.00 [0.08]	51	0.19
Crude palm oil	Agri	-7.18 [-0.85]	3.01** [2.57]	0.03 [0.81]	70	0.13
Crude Oil	Energy	0.30 [0.05]	6.37*** [5.61]	0.01 [0.31]	87	0.31
Cashew	Agri	3.67 [0.83]	1.89** [2.10]	-0.01 [-0.75]	55	0.13
Dhaniya	Agri	14.95* [1.78]	1.45 [0.77]	-0.07 [-1.58]	75	0.04
Furnaceoil	Energy	-8.80 [-0.67]	5.67** [2.43]	0.06 [0.86]	49	0.23
Guar Gum	Agri	24.36* [1.66]	2.76* [1.78]	-0.08 [-1.22]	91	0.05

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.4B: Estimated Regression Coefficients of Model 2-NCDEX (contd…)

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Guar Seed	Agri	18.72 [1.32]	1.95 [1.35]	-0.06 [-0.85]	94	0.03
Gold Pure Mumbai Kg	Precious	-14.36 [-1.55]	0.73 [0.52]	0.10** [2.03]	47	0.07
Groundnut Expeller Oil	Agri	-4.86 [-0.64]	1.31 [0.98]	0.04 [0.89]	46	0.04
Groundnut(in shell)	Agri	-8.77 [-1.28]	0.49 [0.51]	0.06 [1.59]	46	0.06
Gold	Precious	5.44 [0.25]	1.61** [2.09]	-0.03 [-0.19]	48	0.04
Gold 100g Ahmd	Precious	-1.84 [-0.40]	-1.74 [-1.43]	0.03 [1.19]	46	0.03
Gur	Agri	6.58 [0.34]	1.89 [1.15]	-0.03 [-0.30]	32	0.03
Gur (Muzaffarnagar)	Agri	-3.29 [-0.55]	1.12 [0.98]	0.03 [0.92]	85	0.02
Jeera	Agri	-2.63 [-0.37]	1.10 [1.14]	0.02 [0.53]	117	0.01
Jute Sacking	Agri	5.49 [0.35]	-0.88 [-0.59]	-0.01 [-0.17]	30	0.01
Raw Jute	Agri	-11.12 [-1.03]	-0.17 [-0.17]	0.07 [1.18]	41	0.03
V 797 Kapas	Agri	-1.70 [-0.27]	2.50*** [2.69]	0.02 [0.65]	99	0.05
Linear LD Polyethylene	Energy	-5.51 [-0.59]	3.80* [1.70]	0.04 [0.67]	34	0.19
Maize	Agri	-7.58 [-0.54]	2.49 [1.33]	0.06 [0.72]	34	0.04
Yellow/Red Maize	Agri	2.93 [0.42]	1.62 [1.34]	0.00 [-0.06]	67	0.03
RM seed oilcake	Agri	-2.56 [-0.32]	0.83 [0.97]	0.04 [0.78]	46	0.02
Masoor Bold	Agri	19.14** [2.32]	4.78*** [2.75]	-0.08* [-1.82]	49	0.25
Menthaoil	Agri	13.34 [0.76]	1.15 [0.88]	-0.06 [-0.69]	50	0.02
Nickel	Non-Precious	-22.33** [-2.13]	2.94 [1.29]	0.11* [1.90]	48	0.20
Potato	Agri	54.76* [1.96]	4.29 [0.62]	-0.30* [-1.72]	32	0.12

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.4C: Estimated Regression Coefficients of Model 2-NCDEX (contd…)

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Polypropylene	Energy	-2.61 [-0.27]	4.93** [2.45]	0.02 [0.40]	34	0.21
Black Pepper	Agri	5.66 [0.88]	2.87** [2.23]	-0.01 [-0.32]	108	0.04
PVC	Energy	14.48 [0.68]	2.95** [2.19]	-0.09 [-0.62]	32	0.13
PVC – Mumbai	Energy	-11.86 [-1.25]	2.23 [1.03]	0.06 [1.19]	34	0.15
RBD Palmolein	Agri	-3.80 [-0.55]	3.02** [2.41]	0.02 [0.54]	75	0.12
Rubber_New	Agri	-31.65** [-2.51]	2.81** [2.27]	0.21** [2.42]	35	0.16
Rubber RSS 4	Agri	-15.20 [-0.78]	2.75 [0.71]	0.10 [1.04]	42	0.02
RM Oil	Agri	11.04 [1.50]	3.33** [2.33]	-0.04 [-1.13]	50	0.19
RM Seed	Agri	2.30 [0.17]	0.92 [0.73]	0.00 [-0.05]	48	0.01
Mustard Seed	Agri	11.84* [1.77]	3.96*** [3.11]	-0.05 [-1.57]	83	0.21
Soymeal (Indore)	Agri	2.00 [0.20]	2.00 [1.18]	0.01 [0.19]	91	0.02
Soyameal Export	Agri	2.86 [0.28]	0.68 [0.39]	0.00 [-0.02]	58	0.01
Sesame Seed	Agri	17.39 [0.83]	5.78 [1.33]	-0.06 [-0.61]	44	0.11
Shankar Kapas(Rajkot)	Agri	2.58 [0.60]	3.59*** [3.39]	0.00 [-0.06]	53	0.22
Silver	Precious	-5.69 [-0.17]	4.47*** [3.65]	0.05 [0.22]	48	0.10
Silver 5Kgs Ahmd	Precious	-5.86 [-0.69]	1.75 [0.64]	0.06 [1.25]	39	0.03
Silver 5 Kgs	Precious	-15.33 [-1.54]	1.52 [0.81]	0.09 [1.68]	34	0.14
Silver 5Kgs Ahmd before 2008	Precious	-7.59 [-0.59]	2.23 [1.16]	0.05 [0.83]	55	0.04
Steel Long (BIS 2830)	NonPrecious	0.68 [0.13]	2.73* [1.77]	0.00 [0.08]	75	0.09

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Table 4.4D: Estimated Regression Coefficients of Model 2-NCDEX (contd…)

Commodity Name	Sector	Expected Inflation(γ)	Unexpected inflation(δ)	Constant	Obs	R^2
Steel Long	NonPrecious	3.86 [0.30]	5.91*** [2.94]	-0.01 [-0.18]	44	0.32
Sugar (M Grade)	Agri	3.81 [0.37]	0.02 [0.02]	-0.03 [-0.38]	45	0.00
Sugar (M Grade) Muzaffarnagar	Agri	-9.64 [-0.90]	-0.18 [-0.17]	0.04 [0.79]	41	0.02
Sugar(M Grade) Kolkata	Agri	-18.97 [-1.18]	0.91 [0.56]	0.09 [1.17]	30	0.06
Soya Bean	Agri	3.72 [0.59]	1.26 [1.02]	-0.01 [-0.33]	130	0.01
Soy oil-refined	Agri	4.89 [1.39]	1.79** [2.58]	-0.02 [-1.17]	130	0.06
Turmeric	Agri	-13.49 [-1.43]	2.90 [1.45]	0.09* [1.68]	124	0.06
Wheat	Agri	-2.34 [-0.41]	-0.61 [-0.29]	0.02 [0.78]	49	0.00
Yellow Peas	Agri	10.64 [1.37]	3.32** [2.41]	-0.04 [-1.09]	35	0.17
Zinc	NonPrecious	-9.64 [-1.30]	2.76 [1.26]	0.05 [1.22]	48	0.11

Note: Robust t-statistics in brackets: *** p<0.01, ** p<0.05, * p<0.1; obs=number of observations. Agri stands for agriculture;; Envi stands for Environmental.

Equation (4.2) assumes that if a particular commodity futures contract offers some protection against expected and unexpected inflation, one would expect the estimated slope coefficients in equation (4.2) to be positive and statistically significant; that is, increases in domestic expected and unexpected inflation lead to contemporaneous increases in the returns on that particular commodity futures contract. A statistically significant value of γ (expected inflation coefficients) and δ (unexpected inflation coefficients) between 0 and 1 would indicate that the particular derivative is only a partial hedge against domestic inflation, whereas values of estimated γ and δ greater than or equal to 1 would indicate that a particular commodity futures contract is a complete hedge. On the other hand, if they are negative and significant then there exists a

negative relationship between the commodity futures and inflation components (expected and unexpected inflation).

From tables 4.3A, 4.3B and 4.3C it is evident that among all the commodity futures contracts which trade on the Multi Commodity Exchange (MCX), only Areca nut (Jahaji) and Coriander are positive and statistically significant in the case of expected inflation and the estimated coefficients of Areca nut (Jahaji) (17.56) and Coriander (19.44) are above one and hence these can be perfectly hedged against expected inflation. On the other hand, Aluminium, Aluminium Mini, ATF, Brent Crude Oil, CFI, Copper, Copper Mini, Coriander, Crude oil, Gold Petal-Delhi, Heating oil, Maize, Refined Soyoil, Rubber, Silver Micro, Thermal Coal, Tin and Turmeric are positive and statistically significant in the case of unexpected inflation. These estimated coefficients range from 2.10 to 8.68. Hence, we can say that according to the estimated model 2, the commodity futures such as Aluminium (2.10), Aluminium Mini (3.11), ATF (4.29), Brent Crude Oil (6.03), CFI (4.76), Copper (3.65),Copper Mini (2.48), Coriander (8.68), Crude oil (3.67), Gold Petal-Delhi (2.44), Heating oil (3.32), Maize (3.44), Refined Soyoil (3.45), Rubber (6.84), Silver Micro (6.05), Thermal Coal (5.42), Tin (5.40) and Turmeric (3.44) can be perfectly hedged against unexpected inflation.

2 Out of 54 commodity futures which trade on the MCX can be successfully hedged against expected inflation and 18 out of 54 commodity futures can be successfully hedged against unexpected inflation. Only two agricultural commodity futures contracts (Arecanut Jahaji and Coriander) which trade on the MCX can be perfectly hedged against expected inflation in India and this is not true for any other commodity futures contract during the sample period. These two commodity futures contracts are not trading anymore. On the contrary, commodity futures which can be perfectly hedged against unexpected inflation do not belong to any specific sector; rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. However, once again these perfectly hedgeable commodity futures belong to the agricultural contracts and this is true in the case of hedging against inflation also. Out of these 18 perfectly hedgeable commodity futures contracts, only the following contracts - Aluminium, Aluminium Mini, Brent Crude, Copper, Copper Mini, crude oil and Gold Petal-Delhi contracts still continue to trade on the MCX and the rest are not traded anymore. Once again, this proves

that it doesn't matter whether the contracts are still trading on the MCX exchange or not, rather they are market (i.e. instrument) specific.

From tables 4.4A, 4.4B, 4.4C and 4.4D, it is evident that among all the commodity futures contracts which trade on the National Commodity and Derivative Exchange (NCDEX), only Castor Disa, Dhaniya (Coriander), Guar Gum, Masoor Bold, Potato and Mustard Seed are positive and statistically significant in the case of expected inflation and the estimated coefficients of Castor Disa (13.20), Dhaniya (Coriander) (14.95), Guar Gum (24.36), Masoor Bold (19.14), Potato (54.76) and Mustard Seed (11.84) are above one and hence these can be perfectly hedged against expected inflation.

On the other hand, Aluminium, Brent Crude Oil, Castor Disa, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi**,** Copper before 2010, Copper since 2010, Indian 31 mm cotton, Medium Staple Cotton, Crude palm oil, Crude Oil, Cashew, Furnace oil, Guar Gum, Gold, Kapas V 797, Linear LD Polyethylene, Masoor Bold, Polypropylene, Black Pepper, PVC, RBD Palmolein, Rubber_New, Rape Mustard Oil, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long(BIS 2830), Steel Long, Soy oil-refined and Yellow Peas are positive and statistically significant in the case of unexpected inflation. These estimated coefficients range from 1.61 to 6.37. Hence, we can say that according to the estimated model 2, commodity futures such as Aluminium (6.26), Brent Crude Oil (5.63), Castor Disa (2.74), Cotton Seed Oilcake (3.16), Cotton Seed Oilcake Kadi (2.83)**,** Copper before 2010 (6.26), Copper since 2010 (2.09), Indian 31MM Cotton (4.09), Medium Staple Cotton (3.17), Crude palm oil (3.01), Crude Oil (6.37), Cashew (1.89), Furnace oil (5.67), Guar Gum(2.76), Gold (1.61), Kapas V 797(2.50), Linear LD Polyethylene (3.80), Masoor Bold (4.78), Polypropylene (4.93), Black Pepper (2.87), PVC (2.95), RBD Palmolein (3.02), Rubber_New (2.81), Rape Mustard Oil (3.33), Mustard Seed (3.96), Shankar Kapas (Rajkot) (3.59), Silver (4.47), Steel Long(BIS 2830) (2.73), Steel Long(5.91), Soy oil-refined (1.79) and Yellow Peas (3.32) can be perfectly hedged against unexpected inflation.

6 Out of 69 commodity futures which trade on the NCDEX can be successfully hedged against expected inflation and 31 out of 69 commodity futures can be successfully hedged against unexpected inflation. The six commodity futures (Castor Disa, Dhaniya, Guar Gum, Masoor Bold, Potato and Mustard Seed) which can be perfectly hedged against expected inflation belong to the agricultural sector and not to any other sector. Only Castor (Disa), Dhaniya and Mustard

Seed contracts are still continuing to trade on the NCDEX and the rest of the three (Guar Gum, Masoor Bold and Potato) are not traded anymore. On the contrary, the thirty one commodity futures contracts which can be successfully hedged against unexpected inflation do not belong to any specific sector; rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. Only the following contracts such as Brent Crude, Cotton Seed Oilcake, Copper since 2010, Crude Oil, Gold, Kapas V 797, RBD Palmolein, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long(BIS 2830) and Soy oil-refined contracts are still continuing to trade on the MCX and the rest are not trading anymore. Once again, this proves that it doesn't matter whether the contracts are still trading on the MCX exchange or not, rather they are market (i.e. instrument) specific.

4.3: Conclusion

We know from chapter two and three that the Indian commodity futures markets are the next best alternative to equities for investment in India and that there exists a tradeoff between risk and returns. Moreover, given the recent rapid growth in the Indian commodity futures market, it is also very important to know whether the Indian commodity futures markets can be hedged against inflation, expected and unexpected inflation or not. Is there an exchange specific bias in hedging against inflation and its components? Does it matter whether the commodity futures contracts still exist (continue to trade) or not and there is any sector specific bias in hedging against inflation and its components? Using regression models, this chapter examined the effectiveness of commodity futures as an inflation hedge for investors over the period January 2004 to December 2014.

The commodity futures which trade on the Multi Commodity Exchange (MCX), such as Aluminium, Aluminium Mini, ATF, Brent Crude Oil, CFI, Copper, Copper Mini, Crude oil, Heating oil, Maize, Refined Soy oil, Rubber, Silver Micro, Thermal Coal, Tin and Turmeric can be perfectly hedged against inflation and unexpected inflation. On the other hand, CER, Gold Petal, Gold Petal-Delhi and Lead can only be hedged against inflation. Similarly, only Areca nut (Jahaji) can be perfectly hedged against unexpected inflation whereas only Coriander can be perfectly hedged against inflation, expected and unexpected inflation. Among these perfectly hedgeable commodity futures, only Aluminium, Aluminium Mini, Brent Crude, Copper, Copper Mini, Crude oil, Gold Petal, Gold Petal-Delhi, Lead and Silver still continue to trade on the

MCX and the rest are not trading anymore. All the commodity futures (except Areca nut (Jahaji) and Coriander) which can be perfectly hedged against expected inflation belong to the agricultural sector whereas other commodity futures which can be perfectly hedged against inflation and unexpected inflation do not belong to any specific sector, rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. However, majority of the perfectly hedgeable commodity futures belong to the agricultural sector.

Similarly, commodity futures which trade on the National Commodity and Derivative Exchange (NCDEX), such as Aluminium, Brent Crude Oil, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper before 2010, Copper since 2010, Indian 31 mm cotton, Medium Staple Cotton, Crude palm oil, Crude Oil, Cashew, Furnace oil, Gold, Kapas V797, Linear LD Polyethylene, Polypropylene, Black Pepper, PVC, RBD Palmolein, Rape Mustard Oil, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830), Steel Long, Soy oil-refined and Yellow Peascan can be perfectly hedged against inflation and unexpected inflation. On the contrary, only Dhaniya (Coriander) and potato can be perfectly hedged against expected inflation and Rubber New can be hedged against unexpected inflation. Similarly, only Castor Disa, Guar Gum, Masoor Bold and Mustard Seed can be perfectly hedged against inflation, expected and unexpected inflation. Among these perfectly hedgeable commodity futures, only Brent Crude, Copper since 2010, Crude Oil, Gold, Kapas V797, RBD Palmolein, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830) and Soy oil-refined still continue to trade on the NCDEX and the rest are not trading anymore. Similar to the MCX, in the case of NCDEX also the commodity futures which can be perfectly hedged against expected inflation belong to the agricultural sector whereas other commodity futures which can be perfectly hedged against inflation and unexpected inflation do not belong to any specific sector rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. However, similar to the MCX in the case of the NCDEX also, majority of the perfectly hedgeable commodity futures belong to the agricultural sector.

On the whole, approximately forty five percent of the commodity futures (either on the MCX or NCDEX or combined) can be perfectly hedged against inflation and unexpected inflation. Moreover these perfectly hedgeable commodities against inflation and unexpected inflation do

not belong to any specific sector, rather they are spread across the agriculture, environmental, energy, precious and non-precious metals sectors. However, majority of the perfectly hedgeable commodity futures belong to the agricultural sector. On the contrary, less than five percent of the commodity futures which can be hedged against expected inflation are specific to the agricultural sector only. Irrespective of the exchange they trade on, commodity futures contracts such as Aluminium, Brent Crude, Copper, Crude oil, Gold, Silver are perfectly hedgeable against inflation and its components. So, whenever there is rise in the inflation, these commodity prices rises and the value of commodity investments backing these goods also increases. Thereby the investor is saved from the inflationary effects.

The following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation, are such as Copper, Crude oil, heating oil, Lead, Maize, Refined Soy oil, Rubber, Thermal Coal, Tin and Turmeric are positively related inflation. Similarly, the NCDEX's commodities such as Castor disa, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper since 2010, Furnace oil, Guar Gum, Gold, Masoor Bold, Polypropylene, PVC, Shankar Kapas (Rajkot) and Yellow Peas are also positively related inflation. These commodity futures can be perfectly hedged against inflation.

CHAPTER 5

VOLATILITY IN THE INDIAN COMMODITY FUTURES MARKETS

5.1: Introduction

Trading in commodities, in both spot and futures markets, as an alternative investment class to traditional portfolios comprising stocks and bonds, has grown significantly across the globe over the last two decades. Commodity markets are volatile and this volatility changes over time, so understanding the behavior of commodity markets' price volatility is important because of the interdependence among the commodity markets as well with other markets. Due to persistent changes in commodity price volatility, traders (financial institutions and individual investors), producers, and end users (consumers) have always been at the receiving end of this market (what matters for both market participants and policy makers are not market price variations per se, but their unpredictability, and the risks they create).

Schwert (1989) shows that the variations of volatility for monthly stock returns on the period 1857-1987 range from a low of 2% in the early 1960s to a high of 20% in the early 1930s. Similarly, Kroner (1995) shows that the average annualized volatility of non-oil commodity prices hover around 15 percent to 50 percent. Nazlioglu et al. (2013) shows that the spot price of WTI crude oil increased from $25.56 per barrel in January 1986 to over $145 in July 2008 and it fell to $30.28 on December 23, 2008. Then onwards it has been fluctuating and is currently trading at $49.15 as on 15th October 2015. From crude oil prices itself we can see how volatile commodity markets are; there are many other markets which are directly or indirectly connected to the crude oil markets (or the energy sector) and are thereby exposed to higher volatility. For example, Xiaodong Du et al. (2011) concisely explain the interrelationship between the agricultural and energy markets. For example, crude oil impacts corn which has been used as a source of fuel (viz., ethanol) and thereby impacts other agricultural commodity prices also. This

transmission occurs in two ways - a rise in the inputs costs and an increase in the demand for corn. The rise in the prices of inputs and demand for corn further spread into other crops ultimately leading to a rise in food prices due to a fixed number of acres of crop production and the fact that the supply of commodities is highly inelastic. In addition, large demand shocks can easily lead to big swings in spot and future prices over the short run.

Not only do interdependencies among commodity markets and its own market fluctuations contribute to the volatility in commodity futures, financial markets also contribute to commodity futures volatility due to lump sum investments in the commodity indices. In order to offset the risk in financial markets, financial institutions purchase the index linked commodity futures contracts. Any deviation from the fundamental demand and supply equilibrium in the cash market will lead to a rise in price volatility in the commodity futures markets. Since the index investor's trade only in the futures markets and any additional demand by them will lead to a deviation in the supply and demand equilibrium conditions, thereby contributing to the volatility in commodity futures markets (Xiaodong Du et al., 2011).

Since volatility is the major input in the pricing of commodity futures, any sudden change in it will have important ramifications not only for the pricing of commodity futures but also for the construction of optimal hedge ratios. Most of the commodity futures undergo alternating periods of calm and turbulence, any improper assumptions or estimation procedures of volatility will lead to a huge financial loss. Hence, there is a need to systematically evaluate the underlying asset volatility irrespective of the market, sector and country where it belongs and is traded.

The remainder of the chapter is organized as follows: section 2 presents the relevant literature review, section 3 describes the data and methodology, section 4 reports the empirical results and presents a discussion of the volatility analysis and section 5 presents the conclusion.

5.2: Literature Review

A substantial body of research has examined commodity futures markets volatility but when compared to equity market volatility studies, the volume of research studies is very small and also negligible in the case of developing economies when compared to developed economies. Commodity futures markets volatility has been studied from different perspectives such as its determinants, long memory, spillover effects and impacts, interrelationships with other markets

and as well as with other key market (trading volume and market depth etc.) and macroeconomic factors. There are also studies from time to time which presented the latest findings with regard to the literature on commodity futures volatility (Gray and Routledge, 1971; Kamara, 1982; Brorsen and Irwin, 1987; Tomek and Peterson, 2001; Poon and Granger, 2003; Garcia and Luethold, 2004; and Skiadopoulos, 2013).

The following paragraphs document the commodity futures volatility literature from different perspectives. Several studies have examined the presence of volatility persistence and asymmetry in the commodity futures (Black, 1976; Morana, 2001; Sadorsky, 2002; Chang et al., 2013; Liu et al., 2014; Todorova et al., 2014; Behmiri and Manera, 2015). It has been found that volatility is not constant rather it is a time varying phenomenon (Kenyon et al., 1987; Pindyck, 2004; Seifert et al., 2008; Benz and Truck, 2009). Studies have linked liberalization policies to higher volatility (Yang et al., 2001 and Bhar and Hamori, 2008; Babcock, 2012). It has also been found that volatility is an increasing function of either scarcity or low inventories (Fama and French, 1988; Williams and Wright, 1991; Geman and Nguyen, 2005). On the other hand, some studies report that both high and low levels of inventory induce high price volatility (Routledge et al., 2000; Lien and Yang, 2008; Kogan et al., 2009). Similarly, it has been found that information asymmetry also leads to higher volatility (Deaton and Laroque, 1992). In contrast to the above studies, Carbonez et al. (2010) report no empirical relationship between inventories and price volatility. On the other hand, Yang and Brorsen (1993) report chaotic behavior and Adrangi and Chatrath (2002) find evidence of nonlinear prices behavior in the case of metals futures.

Commodity futures are also found to show asymmetry and long memory properties (Jin and Frechette**,** 2004; Figuerola- Ferretti and Gilbert, 2008; Choi and Hammoudeh, 2009; Hammoudeh et al., 2010; Power and Turvey 2010; Arouria et al., 2012; Chkili et al., 2014). Recent studies such as Jin and Frechette **(**2004), Power and Turvey (2010) and Gil-Alana and Tripathy (2014) confirm strong long-term dependence in the agricultural commodity futures. Increased demand for ethanol and biodiesel led to the volatility transmission mechanism and spillover effects between energy and agricultural commodity futures (Oberndorfer, 2009; Kaufmanna and Ullman, 2009; Chang and Su, 2010; Busse et al., 2010; Du et al., 2011; Liu and An, 2011; Serra, 2011; Gardebroek and Hernandez, 2013; Nazlioglu et al., 2013; Beckmann and Czudaj, 2014; Todorova et al., 2014).

Determinants of volatility range from macroeconomic variables (Batten et al., 2010), trading volume and open interest (Garcia et al., 1986; Najand and Yung, 1991; Bessembinder and Seguin, 1993; Foster 1995; Fung and Patterson, 2001; Liu, 2002; Sahadevan, 2002; Yang et al., 2005) equity market (Cochrane et al., 2012; Nissanke, 2012) to spot prices (Yang et al., 2005; Seifert et al., 2008; Benz and Truck, 2009).

5.3: Data and Methodology

5.3.1: Data

The choice of representative prices to analyze price volatility and their frequency is of crucial importance. In the literature it is proved that high frequency prices exhibit higher volatility compared to low frequency. Following the literature, we utilize the daily closing commodity futures price data in this chapter for better understanding volatility in the Indian commodity futures markets. We have drawn data from the National Commodity and Derivatives Exchange (NCDEX) and Multi Commodity Exchange (MCX). The reason for focusing only on these two exchanges is that they constitute about 96.19 [10]percent of the total commodity futures markets in India. The sample period starts from 1st January 2004 to 31st December 2014. The sample thus consists of 43 commodity futures from the MCX and 53 commodity futures from NCDEX.

5.3.2: Generalized Auto Regressive Conditional Heteroskedasticity (GARCH (1, 1) model

Let us assume that the return on an asset is

$$r_t = \mu + \sigma_t \epsilon_t \qquad (5.1)$$

Where that $\epsilon_t \, is$ a sequence of N (0, 1) independently and identically distributed random variables. The residual return at time t, $r_t - \mu$, may be written as

$$a_t = \sigma_t \epsilon_t$$

[10]Forward Market Commission Annual Report (2013-14).

We know from the Autoregressive Conditional Heteroscedasticity (ARCH) model developed by Robert Engel (1982) that

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 \qquad (5.2)$$

Where $\alpha_0 > 0$ and $\alpha_1 \geq 0$ to ensure positive variance and $\alpha_1 < 1$ for stationarity. The ARCH (5.1) model indicates that if the residual return, a_t is large in magnitude the next period's conditional volatility will be σ_{t+1}. This model essentially says that returns are conditionally normal (i.e. conditional on all information up to time t-1). Let us assume that an event happened recently, but according to the ARCH model, the variance at time t can be predicted using all the past information available up to time t-1, however very distant historical information may not be relevant in predicting the variance at time t. This leads to an extension of the ARCH model to the GARCH model, or Generalized Autoregressive Conditional Heteroskedasticity (GARCH) developed by Bollerslev (1986), which is similar in spirit to an ARMA model. In a GARCH (1, 1) model

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (5.3)$$

Where $\alpha_0 > 0$, $\alpha_1 > 0$,$\beta_1 > 0$ and $\alpha_1 + \beta_1 < 1$, so that the next period's forecast of variance is a sum of the last period's forecast and period's squared return. Since a_t is a stationary process then the

$$Var(a_t) = \frac{\alpha_0}{1-\alpha_1-\beta_1} \qquad (5.4)$$

And since $a_t = \sigma_t \epsilon_t$, the unconditional variance of returns, $E[\sigma_t^2] = E[a_t^2]$, which can also be written as $\alpha_0 / (1 - \alpha_1 - \beta_1)$. Then we can rewrite the GARCH (1, 1) model in the following manner from equation (5.3):

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (5.3)$$

$$= (1 - \alpha_1 - \beta_1) E[\sigma^2] + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (5.5)$$

Essentially, equation (5.5) says that next period's conditional variance is a weighted combination of the unconditional variance of returns, $E[\sigma^2]$, and last period's squared residuals and last period's conditional variance, σ_{t-1}^2, with weights $(1 - \alpha_1 - \beta_1)$, α_1, and β_1, which sum to one.

5.3.3: The Integrated GARCH (IGARCH) model

It is very well known that conditional volatility is persistent in financial time series (Enders (2004); Tsay (2010)). As Nelson (1990) argued, the underlying distribution of an asset's return can have a parsimonious representation if the constraint $\alpha_1 + \beta_1 = 1$; therefore in some aspects this constraint forces the conditional variance to act like a process with a unit root (Enders, 2004). Hence the Integrated Generalized Autoregressive Conditional Heteroskedasticity (i.e. IGARCH) models are unit root models. The impact of the past squared shocks $\eta_{t-i} = a_{t-i}^2 - \delta_{t-i}^2$ for i > 0 on a_t^2 is persistent in the IGARCH models and this is the key feature of this model. Then IGARCH (1,1) model can be written as:

$$a_t = \sigma_t \epsilon_t$$

$$\sigma_t^2 = \alpha_0 + \beta_1 \sigma_{t-1}^2 + (1 - \beta_1) a_{t-1}^2 \qquad (5.6)$$

Where that ϵ_t is a sequence of N (0, 1) independently and identically distributed random variables and $1 > \beta_1 > 0$.

5.3.4: Asymmetric GARCH Models (EGARCH (1, 1) and TGARCH (1, 1) Models

The GARCH (1,1) model enforces a symmetric response of volatility to positive and negative news (shocks). However, a negative shock to the return series is likely to increase volatility more than a positive shock of the same magnitude (Black, 1976) and this phenomenon is known as the leverage effect. In order to overcome the shortcomings of the symmetric GARCH models, Nelson (1991) proposed the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model to allow for asymmetric effects. EGARCH models do not impose any nonnegative constraints on the parameters, since they model the log of the conditional variance. On the other hand, the symmetric GARCH models impose the following on the parameters: $\alpha_0 > 0$, $\alpha_1 > 0$, $\beta_1 > 0$. The EGARCH models may be written as follows: (The notations follow Tsay, 2010).

$$\log(\delta_t^2) = \alpha_0 + \sum_{i=1}^{q} \alpha_i \frac{|\alpha_{t-i}|+\gamma_i a_{t-i}}{\delta_{t-i}} + \sum_{j=1}^{p} \beta_j \log(\delta_{t-j}^2) \qquad (5.7)$$

Where a positive a_{t-i} contributes $\alpha_i (1+\gamma_i)|\epsilon_{t-i}|$ to the log volatility. On the other hand, negative a_{t-i} leads to $\alpha_i (1-\gamma_i)|\epsilon_{t-i}|$, where$\epsilon_{t-i} = \frac{a_{t-i}}{\delta_{t-i}}$. Thus the parameter γ_i signifies the leverage effect of a_{t-i}. The leverage effect can be tested in real applications by hypothesizing that $\gamma_i < 0$. It is assumed that bad news will have a larger impact on volatility, hence we would expect the γ_i to be negative.

Another asymmetric GARCH model commonly used to handle leverage effects is the Threshold Generalized Autoregressive Conditional Heteroskedasticity (TGARCH) model. This model divides the distribution of innovations into two disjunctive intervals and then approximates a piece wise linear function for the conditional variance (Glosten et al., 1993). Through the inclusion of lagged conditional variances as a regressor, Zakoian (1994) extended the Threshold model to account for leverage effects.

A TGARCH (p,q) model can be written in the following way:

$$\delta_t^2 = \alpha_0 + \sum_{i=1}^{q} (\alpha_i + \gamma_i N_{t-i}) a_{t-i}^2 + \sum_{j=1}^{p} \beta_j (\delta_{t-j}^2) \qquad (5.8)$$

Where N_{t-i} is an indicator for negative a_{t-i}, that is,

$$N_{t-i} = \begin{cases} 1 \; if \;\; a_{t-i} < 0, \\ 0 \; if \;\; a_{t-i} \geq 0, \end{cases}$$

Where α_i, γ_i, and $\beta_j$are nonnegative parameters. From the above equation it can be seen that a positive a_{t-i} contributes $\alpha_i a_{t-i}^2$to δ_t^2, whereas a negative a_{t-i} has a larger impact $(\alpha_i + \gamma_i) a_{t-i}^2$ with $\gamma_i > 0$. The model uses zero as its threshold to separate the impact of past shocks. This model is also known as the GJR model, since Glosten, Jagannathan and Runkel (1993) proposed essentially same model.

5.4: Results and Discussion

This section provides the estimated results and their interpretation of the four models.

Table 5.1A: Estimated GARCH (1,1) model parameters-MCX

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs	ML	HL
Almond	Agri	0.17*** [7.56]	0.73*** [22.48]	0.00*** [6.77]	960	3.7	7.6
Aluminium	NP	0.04*** [3.04]	0.88*** [17.65]	0.00** [2.11]	1112	8.3	9.3
Aluminium Mini	NP	0.05*** [8.75]	0.94*** [123.08]	0.00*** [4.48]	2652	16.7	70.0
Areca (Jhaji)	Agri	0.06*** [17.00]	0.93*** [331.51]	0.00*** [10.17]	976	14.3	70.0
ATF	Ene	0.02*** [6.70]	0.97*** [265.82]	0.00*** [3.82]	1212	33.3	70.0
Brent Crude	Ene	0.08*** [8.12]	0.68*** [17.74]	0.00*** [7.13]	1300	3.1	3.5
Cardamom	Agri	0.64*** [26.92]	0.26*** [29.20]	0.00*** [32.82]	2651	1.4	7.6
CER	Envi	0.30*** [16.65]	0.72*** [53.79]	0.00*** [15.36]	1060	3.6	70.0
Chana	Agri	0.04*** [6.78]	0.95*** [144.48]	0.00*** [4.27]	1152	20.0	70.0
Copper	NP	0.06*** [13.30]	0.93*** [174.04]	0.00*** [5.53]	2880	14.3	70.0
Coriander	Agri	0.25*** [11.41]	0.41*** [9.36]	0.00*** [10.93]	1342	1.7	2.7
Cotton	Agri	0.38*** [10.42]	0.03 [1.56]	0.00*** [17.65]	932	1.0	1.8
CPO	Agri	0.05*** [10.93]	0.94*** [158.83]	0.00*** [3.70]	1948	16.7	70.0
Crudeoil	Ene	0.04*** [8.12]	0.95*** [161.27]	0.00*** [4.71]	2960	20.0	70.0
Flake Menthol	Agri	0.15*** [14.00]	0.80*** [37.55]	0.00*** [5.87]	750	5.0	14.5
Gasoline	Ene	0.00*** [8.13]	0.99*** [668.53]	0.00 [-0.48]	914	100.0	70.0
Gold	Prec	0.06*** [19.35]	0.93*** [291.83]	0.00*** [8.12]	3263	14.3	70.0
Gold Guinea	Prec	0.08*** [19.78]	0.91*** [222.61]	0.00*** [9.12]	1973	11.1	70.0
Gold Mini	Prec	0.06*** [21.04]	0.93*** [319.82]	0.00*** [9.24]	3263	14.3	70.0
Gold Petal	Prec	0.18*** [14.54]	0.80*** [75.30]	0.00*** [7.74]	1072	5.0	35.3
Heatingoil	Ene	0.01*** [10.80]	0.98*** [1484.75]	0.00 [-0.70]	1044	50.0	70.0
Kapaskhali	Agri	0.04*** [95.46]	0.00 [0.11]	0.00*** [79.58]	2379	1.0	1.2

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept); Obs= no of Observations; ML- Mean Lag; HL= Half-Life figure value.

Table 5.1B: Estimated GARCH (1,1) model parameters-MCX (contd…)

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs	ML	HL
Lead	NP	0.03*** [8.99]	0.96*** [210.35]	0.00** [2.29]	2239	25.0	70.0
Lead Mini	NP	0.04*** [5.96]	0.95*** [103.52]	0.00** [2.48]	1342	20.0	70.0
Maize	Agri	0.31*** [19.67]	0.68*** [42.84]	0.00*** [9.05]	898	3.1	70.0
Menthaoil	Agri	0.35*** [14.43]	0.04*** [4.20]	0.00*** [47.72]	2897	1.0	1.7
Natural Gas	Ene	0.04*** [9.32]	0.95*** [166.25]	0.00*** [4.45]	2528	20.0	70.0
Nickel	NP	0.05*** [10.85]	0.94*** [183.30]	0.00*** [3.46]	2431	16.7	70.0
Nickel Mini	NP	0.05*** [4.65]	0.91*** [41.50]	0.00** [2.27]	857	11.1	18.0
Pepper	Agri	0.21*** [10.55]	0.74*** [47.20]	0.00*** [14.11]	1373	3.8	14.5
Platinum	Prec	0.14*** [22.41]	0.85*** [142.79]	0.00*** [13.70]	1155	6.7	70.0
Refined Soyoil	Agri	0.03*** [8.34]	0.95*** [174.86]	0.00*** [5.53]	1386	20.0	35.3
Rubber	Agri	0.13*** [9.64]	0.79*** [43.00]	0.00*** [5.17]	1079	4.8	9.3
Silver	Prec	0.13*** [20.20]	0.83*** [92.85]	0.00*** [11.30]	3262	5.9	18.0
Silver Mini	Prec	0.09*** [18.74]	0.88*** [131.27]	0.00*** [10.00]	3234	8.3	23.8
Soyabean	Agri	0.04*** [4.72]	0.90*** [42.98]	0.00*** [3.96]	823	10.0	12.2
Thermal Coal	Ene	0.14*** [5.78]	0.35*** [7.04]	0.00*** [11.65]	886	1.5	2.0
Tin	NP	0.03*** [10.08]	0.96*** [300.27]	0.00*** [7.98]	1518	25.0	70.0
Turmeric	Agri	0.00*** [9.93]	0.95*** [245.75]	0.00*** [131.37]	1082	20.0	14.5
Urad	Agri	0.08*** [11.42]	0.90*** [116.30]	0.00 [1.32]	788	10.0	35.3
Wheat	Agri	0.62*** [17.46]	0.37*** [31.72]	0.00*** [22.07]	1099	1.6	70.0
Zinc	NP	0.03*** [10.84]	0.96*** [255.21]	0.00*** [3.36]	2616	25.0	70.0
Zinc Mini	NP	0.06*** [6.24]	0.92*** [68.64]	0.00*** [3.39]	1349	12.5	35.3

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious ; Cons=constant (intercept). ; Obs= no of Observations; ML- Mean Lag; HL= Half-Life figure value.

Table 5.2A: Estimated GARCH (1,1) model parameters-NCDEX

Variable	Sector	Alpha(α)	Beta(β)	Con	Obs	ML	HL
Barley	Agri	0.20*** [11.27]	0.69*** [33.64]	0.00*** [10.42]	2433	3.2	6.9
Brent Crude Oil	Ene	0.07*** [13.01]	0.92*** [184.20]	0.00*** [10.45]	2804	12.5	70.0
Castor (Disa)	Agri	0.08*** [8.79]	0.87*** [67.01]	0.00*** [4.92]	1557	7.7	14.5
Castor Seed	Agri	0.07*** [7.64]	0.92*** [93.13]	0.00*** [3.95]	1694	12.5	70.0
Chana	Agri	0.04*** [5.32]	0.94*** [88.79]	0.00*** [2.93]	1824	16.7	35.3
Cotton Seed Oilcake	Agri	0.05*** [5.06]	0.93*** [66.11]	0.00*** [3.16]	1631	14.3	35.3
Cotton Seed Oilcake (Akola)	Agri	0.04*** [4.05]	0.92*** [37.54]	0.00*** [2.67]	1448	12.5	18.0
Cotton Seed Oilcake Kadi	Agri	0.07*** [48.01]	0.92*** [891.00]	0.00*** [8.47]	933	12.5	70.0
Copper before 2010	NP	0.06*** [6.32]	0.92*** [76.12]	0.00*** [3.23]	920	12.5	35.3
Copper since 2010	NP	0.07*** [7.81]	0.89*** [65.08]	0.00*** [4.80]	1598	9.1	18.0
Crude Oil	Ene	0.04*** [8.85]	0.95*** [171.78]	0.00*** [4.34]	2227	20.0	70.0
Dhaniya	Agri	0.10*** [6.59]	0.85*** [40.18]	0.00*** [4.97]	1920	6.7	14.5
Guar Gum	Agri	0.09*** [12.11]	0.88*** [80.17]	0.00*** [7.14]	2355	8.3	23.8
Gold Pure Mumbai Kg	Prec	0.04*** [8.99]	0.95*** [209.96]	0.00*** [3.06]	1200	20.0	70.0
Groundnut Expeller Oil	Agri	0.10*** [15.06]	0.89*** [220.94]	0.00*** [25.56]	1212	9.1	70.0
Groundnut(in shell)	Agri	0.11*** [14.52]	0.88*** [210.87]	0.00*** [13.25]	1212	8.3	70.0

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; cons=Constant (intercept) ; Obs= no of Observations; ML- Mean Lag; HL= Half-Life figure value.

Table 5.2B: Estimated GARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Alpha(α)	Beta(β)	Con	Obs	ML	HL
Gold	Prec	0.10*** [14.35]	0.84*** [77.70]	0.00*** [13.87]	1237	6.3	12.2
Gold 100g (Ahmd)	Prec	0.07*** [9.09]	0.91*** [93.32]	0.00*** [4.73]	1210	11.1	35.3
Gur	Agri	0.24*** [8.43]	0.59*** [15.13]	0.00*** [9.57]	860	2.4	4.7
Gur MZFNR	Agri	0.11*** [10.50]	0.85*** [69.22]	0.00*** [7.25]	2168	6.7	18.0
Jeera	Agri	0.06*** [9.76]	0.93*** [125.65]	0.00*** [5.01]	3004	14.3	70.0
Raw Jute	Agri	0.12*** [8.85]	0.86*** [87.68]	0.00*** [15.52]	1052	7.1	35.3
V 797 Kapas	Agri	0.08*** [8.96]	0.88*** [63.49]	0.00*** [6.24]	2539	8.3	18.0
Maize	Agri	0.08*** [5.44]	0.89*** [46.37]	0.00*** [4.20]	895	9.1	23.8
Yellow/Red Maize	Agri	0.09*** [13.47]	0.91*** [165.08]	0.00*** [5.20]	1753	11.1	70.0
RM seed oilcake	Agri	0.07*** [18.20]	0.92*** [441.03]	0.00*** [22.20]	1203	12.5	70.0
Masoor Bold	Agri	0.14*** [27.18]	0.85*** [243.84]	0.00*** [5.64]	1280	6.7	70.0
Nickel	NP	0.07*** [13.28]	0.92*** [186.36]	0.00*** [15.94]	1270	12.5	70.0
Potato	Agri	0.20*** [4.12]	0.66*** [9.64]	0.00*** [3.74]	835	2.9	5.6
Polypropylene	Ene	0.18*** [12.82]	0.79*** [82.81]	0.00*** [2.94]	897	4.8	23.8
Black Pepper	Agri	0.07*** [9.43]	0.92*** [124.54]	0.00*** [5.40]	2791	12.5	70.0
PVC	Ene	0.05*** [8.61]	0.94*** [130.06]	0.00*** [4.30]	810	16.7	70.0
PVC - Mumbai	Ene	0.16*** [16.65]	0.83*** [118.94]	0.00*** [5.10]	897	5.9	70.0
RBD Palmolein	Agri	0.02*** [6.64]	0.97*** [162.75]	0.00* [1.89]	880	33.3	70.0
Rubber RSS 4	Agri	0.17*** [15.93]	0.82*** [114.47]	0.00*** [23.95]	1096	5.6	70.0

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious ; cons=Constant (intercept) ; Obs= no of Observations; ML- Mean Lag; HL= Half-Life figure value.

Table 5.2C: Estimated GARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Alpha(α)	Beta(β)	Con	Obs	ML	HL
RM Oil	Agri	0.16*** [10.50]	0.83*** [91.71]	0.00*** [16.75]	1306	5.9	70.0
RM Seed	Agri	0.07*** [6.59]	0.90*** [63.84]	0.00*** [3.94]	1233	10.0	23.8
RM Seed Jaipur	Agri	0.09*** [8.63]	0.88*** [71.30]	0.00*** [8.45]	2142	8.3	23.8
Soymeal (Indore)	Agri	0.07*** [29.63]	0.92*** [652.16]	0.00*** [13.71]	1633	12.5	70.0
Soymeal Export	Agri	0.06*** [49.89]	0.93*** [1890.14]	0.00*** [17.96]	1356	14.3	70.0
Shankar Kapas (Rajkot)	Agri	0.08*** [8.67]	0.88*** [91.59]	0.00*** [10.77]	694	8.3	18.0
Silver	Prec	0.08*** [14.07]	0.89*** [109.09]	0.00*** [5.79]	1237	9.1	23.8
Silver 5 Kgs Ahmd	Prec	0.10*** [10.55]	0.85*** [50.21]	0.00*** [5.17]	1033	6.7	14.5
Silver 5 Kgs Delhi	Prec	0.21*** [8.14]	0.72*** [24.24]	0.00*** [5.09]	894	3.6	10.6
Silver Pure Delhi	Prec	0.05*** [12.80]	0.94*** [193.12]	0.00*** [4.78]	1428	16.7	70.0
Steel Long (BIS 2830)	NP	0.16*** [12.04]	0.83*** [65.62]	0.00*** [5.11]	1232	5.9	70.0
Sugar (M Grade)	Agri	0.09*** [7.04]	0.88*** [55.56]	0.00*** [4.80]	1124	8.3	23.8
Sugar (M Grade) MZFNR	Agri	0.40*** [11.11]	0.48*** [12.83]	0.00*** [9.64]	1070	1.9	6.4
Soya Bean	Agri	0.03*** [16.55]	0.96*** [639.43]	0.00*** [19.41]	3314	25.0	70.0
Soy oil-refined	Agri	0.10*** [9.06]	0.89*** [70.75]	0.00*** [4.26]	1824	9.1	70.0
Turmeric	Agri	0.09*** [10.02]	0.89*** [89.40]	0.00*** [8.37]	3162	9.1	35.3
Yellow Peas	Agri	0.13*** [14.79]	0.83*** [138.22]	0.00*** [12.72]	927	5.9	18.0
Zinc	NP	0.08*** [18.40]	0.91*** [318.31]	0.00*** [21.70]	1270	11.1	70.0

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious ; cons=Constant (intercept) ; Obs= no of Observations; ML- Mean Lag; HL= Half-Life figure value.

From tables 5.1A and 5.1B, it is evident that all the commodity futures of MCX satisfy the non-negativity constraints of the GARCH (1,1) model, since all commodity futures contracts coefficients (ARCH (α) and GARCH (β)) are positive and statistically significant except Cotton and Kapashkhali. Almost all the commodity futures contract satisfies other criteria of the GARCH model that they sum to less than unity (α+β < 1). The economic interpretation of this constraint is that volatility shocks are quite persistent in these commodity futures contracts. Commodity futures contracts such as Cardamom, Mentha oil and Wheat possess larger α coefficients compared to β coefficients, which means that recent news influences these commodity futures price changes to a greater extent than older news and we can say that the shocks are more pronounced in the subsequent periods. On the contrary, in all the other commodity futures other than Cardamom, Mentha oil and Wheat, the β (persistent) coefficients are much higher than the (news) α coefficients, which means that older news influences these commodity futures price changes to a greater extent when compared to recent news, hence their conditional variance displays more autoregressive persistence. The ARCH coefficients range from 0.00 to 0.64 and the average turns out to be 0.13. On the other hand, the GARCH coefficients range from 0.00 to 0.99 and the average turns out to be 0.78. The average sum of the α+β turns out be 0.90.

More than half of the commodity futures of the MCX's GARCH coefficients average sum α+β are greater than 0.90, which indicates that the process is integrated. It is very well established in the literature that in order to examine how long shock effects remain in the process (i.e. the persistence) we need to use the half-life figures, which give the number of days over which a shock to volatility diminishes to half its original size (Lamoureux and Lastrapes, 1990b). The half-life figure depends only on the sum of α+β and is given by:

$$\lambda = 1 - \left(\frac{log2}{\log(\alpha+\beta)}\right) \qquad (5.9)$$

Depending on the commodity futures, the half-life value varies from 1.2 days to 70 days, but the mean of the estimated half-life value of the MCX exchange is 42.87 days. It takes 42.87 days on an average on the MCX exchange for a shock to volatility to diminish to half its original size. The estimated average mean lag of the variance $ML = \left[\frac{1}{(1-\beta)}\right]$ of the MCX's commodity futures

range from 1 day to 100 days and the average turns out to be 14 days for shocks to come through in the model.

On the whole, the MCX's GARCH parameter estimates (α and β) are consistent with those in the literature and GARCH (persistence) coefficients are higher than the ARCH (news) coefficients. Persistence of the shocks (evident from GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures, rather they are present in all the sectors of the MCX's commodity futures during the sample period. On the other hand, the news impact parameters are strong (establishing the ARCH coefficients dominance over the GARCH coefficients) only in a few agricultural commodity futures (Cardamom, Mentha oil and Wheat).

Similarly, from table 5.2A, 5.2B and 5.2C it is evident that all the commodity futures of NCDEX satisfy the non-negativity constraints of the GARCH (1,1) model, since all commodity futures contracts coefficients (ARCH (α) and GARCH (β)) are positive and statistically significant. All commodity futures contract satisfy another criteria of the GARCH model that they sum to less than unity ($\alpha+\beta < 1$), the economic interpretation of this constraint is that volatility shocks are quite persistent in these commodity futures contracts. None of the ARCH coefficients are higher than the GARCH coefficients. All commodity futures β coefficients are much higher than the α coefficients, which means that older news influences these commodity futures price changes rather than recent news, hence their conditional variance displays more autoregressive persistence and there is no role for new information in changing commodity futures price volatility. The ARCH coefficients range from 0.02 to 0.40 and the average turns out to be 0.10. On the other hand, the GARCH coefficients range from 0.48 to 0.97 and the average turns out to be 0.86. The GARCH coefficients are much higher than the ARCH coefficients on the NCDEX, indicating more autoregressive persistence in the conditional variance. The average sum of the $\alpha+\beta$ turns out be 0.97.

Similar to the MCX exchange, the NCDEX's commodity futures combined ARCH and GARCH coefficients average sum for $\alpha+\beta$ is greater than 0.97, which indicates that the process is integrated. In order to see how long shock effects remain in the process, here also we estimate the half-life figure and mean lag values. Depending upon the commodity futures, the half-life value varies from 4.7 days to 70 days, but the mean of the estimated half-life value of the NCDEX exchange is 43.89 days, which means it takes 43.89 days on an average on the NCDEX

exchange for a shock to volatility to diminish to half its original size. The estimated mean lag of the variance $ML = \left[\frac{1}{(1-\beta)}\right]$of the NCDEX's commodity futures range from 1.9 days to 33.3 days and the average turns out to be 10 days for shocks to come through in the model.

On the whole, the NCDEX's GARCH parameter estimates (α and β) are consistent with those in the literature and GARCH (persistence) coefficients are higher than the ARCH (news) coefficients. Persistence of the shocks (evident from the GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures, rather they are present in all the sectors of the MCX's commodity futures during the sample period. On the other hand, we do not find evidence of the ARCH coefficients dominance over the GARCH coefficients.

Both the exchanges (MCX and NCDEX) satisfy the GARCH (1,1) constraints. It is true for both the exchanges that the conditional variance displays more autoregressive persistence because volatility reacts more intensively to market movements. Persistence of the shocks (evident from the GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures rather they are present in all the sectors.

Table 5.3A: Estimated IGARCH (1,1) model parameters-MCX

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs
Almond	Agri	0.28***[10.93]	0.72***[28.53]	0.00***[8.07]	960
Aluminium	NP	0.02***[5.17]	0.98***[211.52]	0.00*[1.70]	1112
Aluminium Mini	NP	0.05***[10.00]	0.95***[177.82]	0.00***[4.31]	2652
Areca Jhaji	Agri	0.07***[26.47]	0.93***[352.13]	0.00***[10.23]	976
ATF	Ener	0.03***[7.68]	0.97***[260.09]	0.00**[2.27]	1212
Brent Crude	Ener	0.02***[12.02]	0.98***[519.41]	0.00***[4.98]	1300
Cardamom	Agri	0.73***[88.06]	0.27***[32.67]	0.00***[34.97]	2651
CER	Envi	0.27***[19.17]	0.73***[53.06]	0.00***[15.13]	1060
Chana	Agri	0.05***[7.98]	0.95***[154.08]	0.00***[4.44]	1152
Copper	NP	0.07***[14.53]	0.93***[199.10]	0.00***[6.03]	2880
Coriander	Agri	0.75***[22.94]	0.25***[7.50]	0.00***[16.54]	1342
Cotton	Agri	0.97***[35.46]	0.03[1.20]	0.00***[16.03]	932
CPO	Agri	0.06***[11.68]	0.94***[184.58]	0.00***[4.74]	1948
Crudeoil	Ener	0.04***[8.95]	0.96***[191.87]	0.00***[5.03]	2960
Flake Menthol	Agri	0.09***[11.80]	0.91***[113.40]	0.00***[6.13]	750
Gasoline	Ener	0.01***[9.00]	0.99***[724.79]	-0.00***[-3.22]	914
Gold	Prec	0.06***[20.72]	0.94***[308.81]	0.00***[8.71]	3263
Gold Guinea	Prec	0.09***[22.70]	0.91***[218.82]	0.00***[10.01]	1973
Gold Mini	Prec	0.07***[24.00]	0.93***[324.19]	0.00***[10.12]	3263
Gold Petal	Prec	0.20***[19.15]	0.80***[79.01]	0.00***[8.68]	1072
Heatingoil	Ener	0.01***[19.36]	0.99***[1898.89]	-0.00***[-5.82]	1044
Kapaskhali	Agri	1.00***[435.67]	0.00[0.10]	0.00***[64.27]	2379

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept); Obs= no of Observations.

Table 5.3B: Estimated IGARCH (1,1) model parameters-MCX (contd…)

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs
Lead	NP	0.04***[9.16]	0.96***[223.98]	0.00**[2.41]	2239
Lead Mini	NP	0.04***[6.99]	0.96***[175.93]	0.00*[1.94]	1342
Maize	Agri	0.32***[22.94]	0.68***[48.90]	0.00***[11.92]	898
Menthaoil	Agri	1.00***[224.65]	0.00*[1.87]	0.00***[53.18]	2897
Natural Gas	Ener	0.05***[10.24]	0.95***[186.15]	0.00***[4.25]	2528
Nickel	NP	0.06***[11.86]	0.94***[196.39]	0.00***[3.69]	2431
Nickel Mini	NP	0.05***[5.44]	0.95***[96.17]	0.00**[2.17]	857
Pepper	Agri	0.27***[21.00]	0.73***[55.38]	0.00***[14.46]	1373
Platinum	Prec	0.13***[18.36]	0.87***[127.26]	0.00***[11.24]	1155
Refined Soyoil	Agri	0.03***[12.42]	0.97***[348.56]	0.00***[5.18]	1386
Rubber	Agri	0.21***[10.81]	0.79***[41.29]	0.00***[5.95]	1079
Silver	Prec	0.14***[20.73]	0.86***[122.82]	0.00***[12.30]	3262
Silver Mini	Prec	0.10***[19.73]	0.90***[173.80]	0.00***[10.75]	3234
Soyabean	Agri	0.01***[9.73]	0.99***[644.72]	0.00***[4.56]	823
Thermal Coal	Ener	0.80***[40.64]	0.20***[9.96]	0.00***[27.09]	886
Tin	NP	0.04***[11.72]	0.96***[308.71]	0.00***[7.43]	1518
Turmeric	Agri	1.00***[3287.21]	0.00***[16.26]	0.00***[107.93]	1082
Urad	Agri	0.09***[12.71]	0.91***[129.78]	0.00***[3.85]	788
Wheat	Agri	0.50***[37.28]	0.50***[37.46]	0.00***[21.52]	1099
Zinc	NP	0.04***[11.96]	0.96***[256.02]	0.00***[3.53]	2616
Zinc Mini	NP	0.07***[7.05]	0.93***[94.29]	0.00***[3.31]	1349

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.4A: Estimated IGARCH (1,1) model parameters-NCDEX

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs
Barley	Agri	0.30***	0.70***	0.00***	2433
		[18.26]	[41.75]	[11.40]	
Brent Crude Oil	Ener	0.09***	0.91***	0.00***	2804
		[20.76]	[217.04]	[10.11]	
Castor Disa	Agri	0.10***	0.90***	0.00***	1557
		[11.54]	[100.55]	[5.18]	
Castor Seed	Agri	0.08***	0.92***	0.00***	1694
		[9.07]	[107.57]	[4.19]	
Chana	Agri	0.04***	0.96***	0.00**	1824
		[6.36]	[145.70]	[2.51]	
Cotton Seed Oilcake	Agri	0.06***	0.94***	0.00***	1631
		[6.35]	[108.33]	[2.76]	
Cotton Seed Oilcake Akola	Agri	0.03***	0.97***	0.00**	1448
		[7.44]	[261.05]	[2.00]	
Cotton Seed Oilcake Kadi	Agri	0.07***	0.93***	0.00***	933
		[101.81]	[1329.35]	[26.31]	
Copper before 2010	NP	0.06***	0.94***	0.00***	920
		[6.96]	[102.39]	[2.91]	
Copper since 2010	NP	0.08***	0.92***	0.00***	1598
		[9.61]	[115.02]	[4.80]	
Crude Oil	Ener	0.05***	0.95***	0.00***	2227
		[9.87]	[191.71]	[4.77]	
Dhaniya	Agri	0.12***	0.88***	0.00***	1920
		[9.04]	[67.75]	[5.15]	
Guar Gum	Agri	0.09***	0.91***	0.00***	2355
		[12.70]	[129.68]	[7.14]	
Gold Pure Mumbai Kg	Prec	0.05***	0.95***	0.00***	1200
		[11.22]	[221.30]	[4.01]	
Groundnut Expeller Oil	Agri	0.11***	0.89***	0.00***	1212
		[38.73]	[327.17]	[32.25]	
Groundnut(in shell)	Agri	0.10***	0.90***	0.00***	1212
		[45.46]	[404.89]	[16.19]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious,Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.4B: Estimated IGARCH (1,1) model parameters-NCDEX

Variable	Sector	Alpha(α)	Beta(β)	Cons	Obs
Gold	Prec	0.18*** [13.96]	0.82*** [63.99]	0.00*** [13.12]	1237
Gold 100g Ahmd	Prec	0.09*** [10.34]	0.91*** [109.79]	0.00*** [4.38]	1210
Gur	Agri	0.48*** [13.62]	0.52*** [14.85]	0.00*** [10.63]	860
Gur MZFNR	Agri	0.13*** [13.96]	0.87*** [90.55]	0.00*** [7.37]	2168
Jeera	Agri	0.06*** [11.29]	0.94*** [178.48]	0.00*** [4.90]	3004
Raw Jute	Agri	0.63*** [45.63]	0.37*** [26.52]	0.00*** [42.11]	1052
V 797 Kapas	Agri	0.05*** [12.77]	0.95*** [267.70]	0.00*** [3.85]	2539
Maize	Agri	0.10*** [6.67]	0.90*** [61.30]	0.00*** [4.11]	895
Yellow/Red Maize	Agri	0.09*** [16.00]	0.91*** [167.46]	0.00*** [6.64]	1753
RM seed oilcake	Agri	0.07*** [52.82]	0.93*** [661.82]	0.00*** [28.37]	1203
Masoor Bold	Agri	0.13*** [49.45]	0.87*** [337.44]	0.00*** [10.01]	1280
Nickel	NP	0.08*** [20.29]	0.92*** [239.25]	0.00*** [16.56]	1270
Potato	Agri	0.25*** [5.92]	0.75*** [17.51]	0.00*** [3.70]	835
Polypropylene	Ener	0.15*** [34.09]	0.85*** [185.86]	0.00*** [6.02]	897
Black Pepper	Agri	0.07*** [10.62]	0.93*** [139.98]	0.00*** [5.01]	2791
PVC	Ener	0.07*** [9.50]	0.93*** [133.63]	0.00*** [4.91]	810
PVC - Mumbai	Ener	0.13*** [31.42]	0.87*** [205.98]	0.00*** [8.25]	897
RBD Palmolein	Agri	0.03*** [7.05]	0.97*** [223.49]	0.00*** [2.58]	880
Rubber RSS 4	Agri	0.16*** [29.33]	0.84*** [148.42]	0.00*** [28.50]	1096
RM Oil	Agri	0.03*** [140.96]	0.97*** [5240.57]	0.00*** [21.60]	1306

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.4C: Estimated IGARCH (1,1) model parameters-NCDEX (contd…)

Variable-	Sector	Alpha(α)	Beta(β)	Cons	Obs
RM Seed	Agri	0.07*** [8.41]	0.93*** [105.67]	0.00*** [4.01]	1233
RM Seed Jaipur	Agri	0.12*** [11.78]	0.88*** [88.88]	0.00*** [9.41]	2142
Soymeal (Indore)	Agri	0.07*** [86.69]	0.93*** [1106.34]	0.00*** [20.96]	1633
Soymeal Export	Agri	0.06*** [212.44]	0.94*** [3227.99]	0.00*** [36.98]	1356
Shankar Kapas (Rajkot)	Agri	0.14*** [17.34]	0.86*** [104.40]	0.00*** [14.41]	694
Silver	Prec	0.09*** [16.23]	0.91*** [162.91]	0.00*** [6.82]	1237
Silver 5 Kgs Ahmd	Prec	0.08*** [10.34]	0.92*** [114.56]	0.00*** [5.47]	1033
Silver 5 Kgs Delhi	Prec	0.26*** [10.11]	0.74*** [29.40]	0.00*** [5.39]	894
Silver Pure Delhi	Prec	0.06*** [13.34]	0.94*** [224.18]	0.00*** [5.67]	1428
Steel Long (BIS 2830)	NP	0.17*** [13.53]	0.83*** [66.17]	0.00*** [6.53]	1232
Sugar (M Grade)	Agri	0.12*** [8.84]	0.88*** [65.86]	0.00*** [4.73]	1124
Sugar (M Grade) MZFNR	Agri	0.55*** [16.82]	0.45*** [13.65]	0.00*** [11.51]	1070
Soya Bean	Agri	0.03*** [23.45]	0.97*** [741.92]	0.00*** [12.23]	3314
Soy oil-refined	Agri	0.11*** [9.85]	0.89*** [82.36]	0.00*** [4.89]	1824
Turmeric	Agri	0.08*** [12.27]	0.92*** [138.28]	0.00*** [8.07]	3162
Yellow Peas	Agri	0.14*** [30.78]	0.86*** [194.32]	0.00*** [15.46]	927
Zinc	NP	0.08*** [33.39]	0.92*** [381.65]	0.00*** [21.92]	1270

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ene=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

We can find that the sum of the GARCH (1,1) model parameters is very close to unity provided we have long time series data. Nelson (1991) argued that an asset returns distribution could be parsimonious if we constrain $\alpha + \beta = 1$. The GARCH (1,1) analysis on the both (MCX and NCDEX) exchanges indicates that in most of the commodity futures persistence coefficients (i.e. sum of the $(\alpha + \beta \approx 1)$) turn out to be approximately unity, which indicates that the process is integrated and hence we proceed with the Integrated GARCH analysis. Though not all the commodity futures' ARCH and GARCH coefficient sums are not approximately unity, nevertheless we conducted the IGARCH analysis on all commodity futures of the MCX and NCDEX exchanges for the sake of completeness during the sample period.

Since the IGARCH (1,1) model imposes the $\alpha + \beta = 1$ constraint, from table 5.3A and 5.3B it is evident that all the ARCH and GARCH coefficients sum to unity. All the commodity futures of the MCX satisfy the non-negativity constraints of the IGARCH (1,1) model, since all commodity futures contracts coefficients (ARCH (α) and GARCH (β)) are positive and statistically significant. Commodity futures contracts such as Cardamom, Coriander, Cotton, Kapaskhali, Mentha oil, Thermal Coal and Turmeric possesses larger α coefficients compared to the β coefficients, which means that recent news influences these commodity futures price changes to a greater extent compared to older news and we can say that the shocks are more pronounced in the subsequent periods. On the contrary, in all the other commodity futures other than Cardamom, Coriander, Cotton, Kapaskhali, Mentha oil, Thermal Coal and Turmeric, the β (persistence) coefficients are much higher than the (news) α coefficients, which means that older news influences these commodity futures price changes to a greater extent compared to recent news, hence their conditional variance displays more autoregressive persistence. The ARCH coefficients range from 0.01 to 1 and the average turns out to be 0.23. On the other hand, the GARCH coefficients range from 0.00 to 0.99 and the average turns out to be 0.77. The average sum of the α+β turns out be 1.00.

Similarly, from tables 5.4A, 5.4B and 5.4C it is evident that all the ARCH and GARCH coefficients sum to unity. All the commodity futures of the NCDEX satisfy the non-negativity constraints of the IGARCH (1,1) model and all the commodity futures contracts coefficients (ARCH (α) and GARCH (β)) are positive and statistically significant. Commodity futures contracts such as Raw Jute and Sugar M grade (Muzzaffer Nagar) possess larger α coefficients

compared to β coefficients, which means that recent news influences these commodity futures price changes to a greater extent compared to the older news and we can say that the shocks are more pronounced in the subsequent periods. On the contrary, in all the other commodity futures other than Raw Jute and Sugar M grade (Muzaffar Nagar), the β (persistence) coefficients are much higher than the (news) α coefficients, which mean that older news influences these commodity futures price changes rather than recent news, hence their conditional variance displays more autoregressive persistence. The ARCH coefficients range from 0.03 to 63 and the average turns out to be 0.13. On the other hand, the GARCH coefficients range from 0.37 to 0.97 and the average turns out to be 0.87. The average sum of the α+β turns out be 1.00.

The parameters of the IGARCH (1,1) model are very close to the GARCH (1,1) model in most of the commodity futures. All the commodity futures of MCX and NCDEX's intercepts are zero and statistically significant. This phenomenon indicates that the volatility forecasts are simply $\sigma_h^2(1)$ for all forecast horizons. The estimated IGARCH model parameters for all the commodity futures of the MCX and NCDEX exhibit persistence in variance, which means that current information remains important for the forecast of the conditional variance for all horizons in all these commodity futures irrespective of the sector to which they belong. Thus today's information is very crucial for forecasting into the future. Similarly, shocks are permanent to the system and these shocks to the conditional variance will never die out due to the persistence phenomenon. As the ARCH and GARCH coefficients in the IGARCH (1,1) model sum to unity, the half-life figure values cannot be calculated, since log (α+β) approaches zero from below (Lamoureux and Lastrapes, 1990b) and the half-life value becomes infinity. Hence the impacts of the variance never die out.

Table 5.5A: Estimated EGARCH (1,1) model parameters-MCX

Variable	Sector	Gamma(γ)	Alpha(α)	Beta(β)	Cons	Obs
Almond	Agri	-0.08*** [-3.52]	0.27*** [8.59]	0.86*** [46.32]	-1.19*** [-7.68]	960
Aluminium	NP	0.02* [1.84]	0.08*** [3.50]	0.96*** [46.65]	-0.33* [-1.77]	1112
Aluminium Mini	NP	0.01 [1.51]	0.11*** [10.82]	0.99*** [312.18]	-0.11*** [-3.89]	2652
Areca Jhaji	Agri	-0.01 [-1.51]	0.16*** [21.78]	0.97*** [396.47]	-0.18*** [-10.00]	976
ATF	Ener	-0.02*** [-5.58]	0.05*** [7.24]	1.00*** [1453.38]	0.01* [1.85]	1212
Brent Crude	Ener	-0.13*** [-10.77]	0.13*** [9.52]	0.80*** [33.30]	-1.70*** [-8.10]	1300
Cardamom	Agri	-0.27*** [-16.60]	0.47*** [23.85]	0.70*** [74.56]	-2.01*** [-31.02]	2651
CER	Envi	-0.08*** [-11.89]	0.19*** [16.24]	0.97*** [286.46]	-0.22*** [-7.80]	1060
Chana	Agri	-0.10*** [-4.11]	0.31*** [10.33]	0.21* [1.82]	-6.77*** [-6.82]	1072
Copper Mini	NP	-0.01 [-0.61]	0.12*** [5.65]	0.97*** [72.90]	-0.30** [-2.49]	865
Coriander	Agri	0.11*** [4.00]	0.42*** [12.36]	0.49*** [9.35]	-4.19*** [-9.50]	1342
Cotton	Agri	-0.12*** [-4.01]	0.57*** [14.54]	0.09 [1.07]	-8.05*** [-10.08]	932
CPO	Agri	-0.02*** [-5.49]	0.11*** [10.52]	0.99*** [337.89]	-0.10*** [-3.81]	1948
Crudeoil	Ener	-0.02*** [-5.48]	0.09*** [9.10]	0.99*** [570.99]	-0.06*** [-4.48]	2960
Flake Menthol	Agri	-0.06*** [-5.20]	0.24*** [13.06]	0.93*** [66.17]	-0.56*** [-4.97]	750
Gasoline	Ener	-0.01** [-2.39]	0.02*** [9.43]	1.00*** [2288.97]	0.02*** [4.74]	914
Gold	Prec	0.03*** [6.27]	0.13*** [22.75]	0.99*** [720.95]	-0.09*** [-7.39]	3263
Gold Guinea	Prec	0.03*** [5.01]	0.21*** [25.35]	0.98*** [411.00]	-0.19*** [-8.89]	1973
Gold Mini	Prec	0.04*** [7.52]	0.14*** [23.17]	0.99*** [698.56]	-0.11*** [-8.53]	3263
Gold Petal	Prec	0.05*** [3.95]	0.33*** [19.84]	0.94*** [136.65]	-0.50*** [-7.96]	1072
Heatingoil	Ener	-0.05*** [-8.69]	0.01*** [11.69]	1.00*** [994.95]	0.01 [0.79]	1044
Kapaskhali	Agri	0.19*** [46.12]	0.07*** [34.39]	-0.95*** [-449.54]	-15.15*** [-1135.91]	2379

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.5B: Estimated EGARCH (1,1) model parameters-MCX (contd…)

Variable	Sector	Gamma(γ)	Alpha(α)	Beta(β)	Cons	Obs
Lead	NP	-0.01 [-1.26]	0.08*** [9.31]	1.00*** [938.42]	-0.01 [-1.13]	2239
Lead Mini	NP	-0.01 [-0.96]	0.08*** [6.45]	0.99*** [254.32]	-0.07** [-2.19]	1342
Maize	Agri	-0.03** [-2.00]	0.45*** [22.91]	0.84*** [62.53]	-1.38*** [-10.97]	898
Menthaoil	Agri	0.04*** [11.75]	0.03*** [8.18]	0.99*** [825.79]	-0.07*** [-8.95]	2897
Natural Gas	Ener	0.06*** [5.26]	-0.02** [-2.36]	-0.81*** [-18.96]	-13.06*** [-41.93]	2528
Nickel	NP	0.00 [-0.67]	0.12*** [12.44]	0.99*** [523.01]	-0.04** [-2.54]	2431
Nickel Mini	NP	0.02** [2.00]	0.11*** [4.94]	0.98*** [97.74]	-0.15* [-1.68]	857
Pepper	Agri	-0.04** [-2.50]	0.36*** [16.56]	0.87*** [89.92]	-0.95*** [-12.84]	1373
Platinum	Prec	-0.67*** [-10.76]	2.06*** [53.96]	0.19*** [13.42]	-6.13*** [-53.43]	1155
Refined Soyoil	Agri	-0.11*** [-7.34]	0.14*** [7.21]	0.81*** [27.54]	-1.73*** [-6.50]	1386
Rubber	Agri	-0.08*** [-10.43]	0.28*** [14.46]	0.96*** [139.13]	-0.31*** [-5.25]	1079
Silver	Prec	0.02*** [2.87]	0.23*** [24.56]	0.96*** [239.00]	-0.32*** [-9.68]	3262
Silver Mini	Prec	0.02*** [4.53]	0.18*** [22.21]	0.98*** [402.07]	-0.19*** [-9.20]	3234
Soybean	Agri	0.09*** [5.90]	0.00 [-0.22]	-0.88*** [-31.86]	-16.93*** [-63.40]	823
Thermal Coal	Ener	0.09*** [3.00]	0.29*** [7.67]	0.44*** [7.79]	-5.00*** [-9.92]	886
Tin	NP	-0.05*** [-3.32]	0.30*** [14.20]	0.71*** [23.60]	-2.31*** [-9.54]	1518
Turmeric	Agri	0.04 [1.39]	0.41*** [11.82]	-0.50*** [-9.84]	-10.89*** [-28.82]	1082
Urad	Agri	0.03** [2.47]	0.27*** [12.34]	0.98*** [170.58]	-0.09** [-1.98]	788
Wheat	Agri	-0.21*** [-11.96]	0.59*** [21.55]	0.69*** [36.05]	-2.71*** [-16.35]	1099
Zinc	NP	0.01*** [4.50]	0.01*** [3.58]	-0.99*** [-258.52]	-15.93*** [-374.32]	2616
Zinc Mini	NP	0.01 [1.06]	0.15*** [7.02]	0.98*** [145.86]	-0.19*** [-3.14]	1349

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.6A: Estimated EGARCH (1,1) model parameters-NCDEX

Variable-Egarch	Sector	Gamma(γ)	Alpha(α)	Beta(β)	Cons	Obs
Barley	Agri	0.03***	0.00	-0.98***	-17.23***	2433
		[4.95]	[0.79]	[-163.82]	[-276.18]	
Brent Crude Oil	Ener	0.00	0.11***	0.99***	-0.08***	2804
		[0.14]	[20.44]	[735.50]	[-7.49]	
Castor Disa	Agri	0.02**	0.17***	0.97***	-0.28***	1557
		[2.56]	[10.88]	[157.88]	[-4.80]	
Castor Seed	Agri	0.02**	0.15***	0.98***	-0.17***	1694
		[2.45]	[8.07]	[194.20]	[-3.92]	
Chana	Agri	0.01	0.08***	0.99***	-0.12**	1824
		[0.96]	[6.25]	[186.90]	[-2.57]	
Cotton Seed Oilcake	Agri	0.01*	-0.02*	-0.98***	-17.30***	1631
		[1.70]	[-1.80]	[-86.11]	[-153.00]	
Cotton Seed Oilcake Akola	Agri	0.01*	0.06***	0.98***	-0.15**	1448
		[1.86]	[5.82]	[130.44]	[-2.25]	
Cotton Seed Oilcake Kadi	Agri	-0.05***	0.17***	1.00***	0.07***	933
		[-14.46]	[57.69]	[1213.76]	[10.63]	
Copper before 2010	NP	-0.06***	0.10***	0.99***	-0.12***	920
		[-6.34]	[6.00]	[212.78]	[-3.11]	
Copper since 2010	NP	-0.05***	0.13***	0.98***	-0.21***	1598
		[-5.58]	[9.92]	[188.89]	[-4.41]	
Crude Oil	Ener	-0.03***	0.10***	0.99***	-0.08***	2227
		[-4.77]	[9.10]	[475.08]	[-4.41]	
Dhaniya	Agri	0.00	0.22***	0.92***	-0.64***	1920
		[0.14]	[8.02]	[67.08]	[-5.65]	
Guar Gum	Agri	0.04***	0.11***	0.98***	-0.16***	2355
		[7.49]	[11.49]	[361.81]	[-7.15]	
Gold Pure Mumbai Kg	Prec	0.03***	0.07***	1.00***	-0.01	1200
		[5.60]	[7.91]	[786.30]	[-1.32]	
Groundnut Expeller Oil	Agri	-0.15***	0.05***	1.00***	-0.01	1212
		[-25.14]	[29.30]	[1544.07]	[-1.63]	
Groundnut(in shell)	Agri	0.04***	0.12***	0.99***	-0.06***	1212
		[8.17]	[24.29]	[848.45]	[-6.94]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious,Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.6B: Estimated EGARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Gamma(γ)	Alpha(α)	Beta(β)	Cons	Obs
Gold	Prec	0.01 [0.87]	0.24*** [12.46]	0.87*** [66.33]	-1.18*** [-9.47]	1237
Gold 100g Ahmd	Prec	0.07*** [7.78]	0.13*** [10.44]	0.99*** [336.20]	-0.12*** [-4.35]	1210
Gur	Agri	0.05** [2.28]	0.27*** [7.87]	0.89*** [45.30]	-1.01*** [-5.65]	860
Gur MZFNR	Agri	0.06*** [7.16]	0.18*** [11.53]	0.96*** [170.41]	-0.34*** [-6.40]	2168
Jeera	Agri	0.01 [0.83]	0.14*** [10.99]	0.97*** [197.15]	-0.23*** [-5.59]	3004
Raw Jute	Agri	-0.07*** [-5.34]	0.19*** [10.82]	0.95*** [223.28]	-0.38*** [-10.21]	1052
V 797 Kapas	Agri	-0.02*** [-3.71]	0.00 [0.99]	-0.99*** [-195.30]	-17.49*** [-299.42]	2539
Maize	Agri	-0.01 [-0.70]	0.16*** [6.32]	0.94*** [72.19]	-0.55*** [-4.73]	895
Yellow/Red Maize	Agri	0.05*** [4.94]	0.24*** [18.89]	0.97*** [188.19]	-0.26*** [-5.48]	1753
RM seed oilcake	Agri	-0.06*** [-4.96]	0.25*** [25.74]	0.97*** [174.45]	-0.27*** [-5.20]	1203
Masoor Bold	Agri	0.01 [0.97]	0.32*** [32.99]	0.99*** [489.99]	-0.07*** [-3.75]	1280
Nickel	NP	0.06*** [5.18]	-0.04*** [-4.19]	-0.91*** [-54.14]	-14.23*** [-120.84]	1270
Potato	Agri	-0.02 [-0.55]	0.38*** [5.58]	0.82*** [19.98]	-1.42*** [-4.24]	835
Polypropylene	Ener	-0.05*** [-3.97]	0.46*** [20.71]	0.98*** [236.83]	-0.06* [-1.92]	897
Black Pepper	Agri	0.01** [2.09]	0.15*** [10.94]	0.98*** [289.63]	-0.19*** [-6.56]	2791
PVC	Ener	-0.04*** [-3.59]	0.13*** [9.70]	0.98*** [196.58]	-0.17*** [-3.91]	810
PVC - Mumbai	Ener	-0.04*** [-2.99]	0.43*** [22.88]	0.97*** [202.06]	-0.14*** [-3.55]	897
RBD Palmolein	Agri	-0.02*** [-3.15]	0.05*** [7.26]	0.99*** [274.28]	-0.06* [-1.74]	880
Rubber RSS 4	Agri	0.12*** [14.32]	0.18*** [15.27]	0.95*** [185.70]	-0.37*** [-9.02]	1096

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious;Cons=constant (intercept) ; Obs= no of Observations.

Table 5.6C: Estimated EGARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Gamma(γ)	Alpha(α)	Beta(β)	Cons	Obs
RM Oil	Agri	-0.02***	0.08***	0.99***	-0.11***	1306
		[-4.47]	[32.78]	[423.15]	[-4.75]	
RM Seed	Agri	0.01**	0.03***	-0.97***	-18.23***	1233
		[2.02]	[2.89]	[-105.42]	[-182.60]	
RM Seed Jaipur	Agri	0.00	0.17***	0.96***	-0.35***	2142
		[-0.15]	[11.18]	[217.65]	[-8.16]	
Soymeal (Indore)	Agri	-0.02***	0.17***	0.98***	-0.09***	1633
		[-3.81]	[42.84]	[322.91]	[-3.59]	
Soymeal Export	Agri	0.04***	0.04***	-0.92***	-18.12***	1356
		[6.04]	[6.68]	[-54.99]	[-108.74]	
Shankar Kapas(Rajkot)	Agri	-0.06***	0.17***	0.93***	-0.69***	694
		[-4.98]	[11.01]	[140.95]	[-11.27]	
Silver	Prec	0.03***	0.18***	0.97***	-0.25***	1237
		[4.00]	[15.23]	[197.31]	[-6.02]	
Silver 5 Kgs Ahmd	Prec	0.06***	0.09***	0.99***	-0.04***	1033
		[7.36]	[9.64]	[649.78]	[-3.05]	
Silver 5 Kgs Delhi	Prec	0.00	0.38***	0.91***	-0.77***	894
		[0.19]	[9.60]	[52.42]	[-5.12]	
Silver Pure Delhi	Prec	0.02***	0.10***	1.00***	-0.01	1428
		[6.51]	[15.20]	[767.21]	[-0.59]	
Steel Long (BIS 2830)	NP	0.04***	0.29***	0.97***	-0.24***	1232
		[3.51]	[16.04]	[173.05]	[-4.66]	
Sugar (M Grade)	Agri	0.05***	0.18***	0.96***	-0.39***	1124
		[4.47]	[8.30]	[129.89]	[-5.48]	
Sugar (M Grade) MZFNR	Agri	0.11***	0.40***	0.82***	-1.71***	1070
		[5.59]	[10.15]	[35.24]	[-7.79]	
Soya Bean	Agri	-0.07***	0.19***	0.79***	-1.86***	3314
		[-8.67]	[12.96]	[47.69]	[-12.79]	
Soy oil-refined	Agri	-0.02	0.21***	0.96***	-0.33***	1824
		[-1.45]	[11.01]	[134.41]	[-4.86]	
Turmeric	Agri	0.01*	0.17***	0.96***	-0.33***	3162
		[1.83]	[11.82]	[193.63]	[-7.97]	
Yellow Peas	Agri	0.02***	0.01*	-1.00***	-17.61***	927
		[5.18]	[1.86]	[-453.17]	[-519.00]	
Zinc	NP	-0.04***	0.24***	0.96***	-0.25***	1270
		[-3.26]	[23.91]	[204.11]	[-7.05]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=Non-Precious,Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious ; Cons=constant (intercept) ; Obs= no of Observations.

The GARCH (1,1) model enforces a symmetric response of volatility to positive and negative news (shocks). However, a negative shock to the return series is likely to increase volatility more than a positive shock of the same magnitude (Black, 1976) and this phenomenon is known as the leverage effect. To overcome the asymmetry problem in GARCH models, Nelson (1991) proposes the Exponential GARCH model, which allows for asymmetric effects between positive and negative return series.

From tables 5.5A and 5.5B it is evident that there are leverage effects in the commodity futures which belong to the MCX. The leverage effect is negatively significant in the case of Almond, ATF, Brent Crude, Cardamom, CER, Chana, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Tin and Wheat. These commodity futures are markedly affected by bad news (negative shocks). The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this leads to a negative relationship between returns and volatility.

On the other hand, in the case of Aluminium, Coriander, Gold, Gold Guinea, Gold Mini, Gold Petal, Kapaskhali, Menthaoil, Natural Gas, Nickel Mini, Silver, Silver Mini, Soybean, Thermal Coal, Urad, and Zinc the leverage effect is positively significant. These commodity futures are more destabilized by the positive innovations (unanticipated price increases) than the negative innovations. Though the positive leverage effect is strong (i.e. most of the γ coefficients are statistically significant at 1 percent) but this effect is substantially smaller than the symmetric effect (i.e. symmetric effect dominates the asymmetric effect in these commodity futures).

There is no asymmetric effect in the case of Aluminium Mini, Areca Nut Jhaji, Copper Mini, Lead, Lead Mini, Nickel, Turmeric and Zinc Mini, which means that in these commodity futures, volatility is symmetrically affected by negative and positive news. On the whole, there is an asymmetric effect in the case of agriculture, energy and environment sectoral commodity futures and no asymmetric effect in the case of precious and non-precious sectoral commodity futures. In most of the commodity futures, the symmetric effect dominates the asymmetric effect. The leverage effect is significant in the case of agriculture, energy and environment, making precious and non-precious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange.

Similarly, it is also evident from the results presented in tables 5.6A, 5.6B and 5.6C that there are leverage effects in the commodity futures which belong to the NCDEX. The leverage effect is negatively significant in the case of Cotton Seed Oilcake Kadi, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, V 797 Kapas, Rape Mustard seed oilcake, Polypropylene, both the polyvinyl chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soymeal (Indore), Shankar Kapas (Rajkot), Soya Bean and Zinc. These commodity futures are markedly affected by bad news (negative shocks). The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this leads to a negative relationship between returns and volatility.

On the other hand, in the case of Barley, Castor (Disa), Castor Seed, Cotton Seed Oilcake, Cotton Seed Oilcake Akola, Guar Gum, Pure Gold (Mumbai), Groundnut(in shell), Gold 100g (Ahmadabad), Gur, Gur (Muzzafer Nagar), Yellow/Red Maize, Nickel, Black Pepper, Rubber RSS 4, Rape Mustard seed, Soymeal Export, Silver, Silver 5 KGS (Ahmadabad), Silver Pure Delhi, Steel Long (BIS 2830), Sugar (M Grade), Sugar M Grade (Muzzafer Nagar), Turmeric and Yellow Peas the leverage effect is positively significant. Once again similar to the MCX commodity futures, these commodity futures are also more destabilized by positive innovations (unanticipated price increases) than negative innovations. Though the positive leverage effect is strong (i.e. most of the γ coefficients are statistically significant at the 1 percent level of significance) but this effect is substantially smaller than the symmetric effect (i.e. symmetric effect dominates the asymmetric effect in these commodity futures).

There is no asymmetric effect in the case of Brent Crude Oil, Chana, Dhaniya, Gold, Jeera, Maize, Masoor Bold, Potato, Rape Mustard Seed (Jaipur), Silver 5 KGS (Delhi), Soy oil-refined, which means that in these commodity futures volatility is symmetrically affected by negative and positive news. On the whole, there is an asymmetric effect in the case of agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect only in the case of precious sectoral commodity futures. In most of the commodity futures, the symmetric effect dominates the asymmetric effect. The leverage effect is significant in the case of agriculture, energy and energy, making only precious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the NCDEX exchange.

Table 5.7A: Estimated TGARCH (1,1) model parameters-MCX

Variable	Sector	Alpha(α)	Gamma(γ)	Beta(β)	Cons	Obs
Almond	Agri	0.26*** [5.90]	0.20*** [4.79]	0.78*** [29.40]	0.00*** [7.01]	960
Aluminium	NP	0.05*** [2.87]	0.01 [0.47]	0.87*** [17.13]	0.00** [2.09]	1112
Aluminium Mini	NP	0.05*** [7.60]	0.00 [0.08]	0.94*** [122.53]	0.00*** [4.48]	2652
Areca Jhaji	Agri	0.08*** [11.58]	0.02** [2.28]	0.93*** [329.99]	0.00*** [10.52]	976
ATF	Ener	0.03*** [7.07]	0.03*** [6.88]	0.98*** [258.35]	0.00*** [6.23]	1212
Brent Crude	Ener	0.14*** [9.58]	0.13*** [8.67]	0.79*** [40.39]	0.00*** [8.89]	1300
Cardamom	Agri	1.12*** [20.33]	1.07*** [18.81]	0.37*** [34.08]	0.00*** [31.48]	2651
CER	Envi	0.36*** [14.12]	0.27*** [13.41]	0.78*** [48.15]	0.00*** [10.61]	1060
Chana	Agri	0.04*** [5.54]	0.01 [0.82]	0.95*** [144.00]	0.00*** [4.27]	1152
Copper	NP	0.08*** [12.36]	0.03*** [3.93]	0.93*** [176.49]	0.00*** [5.21]	2880
Coriander	Agri	0.21*** [5.45]	-0.14*** [-2.74]	0.32*** [6.26]	0.00*** [11.12]	1342
Cotton	Agri	0.48*** [7.99]	0.22*** [2.93]	0.00 [0.07]	0.00*** [12.94]	932
CPO	Agri	0.07*** [10.77]	0.03*** [6.34]	0.94*** [149.55]	0.00*** [4.16]	1948
Crudeoil	Ener	0.05*** [8.57]	0.03*** [5.33]	0.95*** [160.61]	0.00*** [4.53]	2960
Flake Menthol	Agri	0.27*** [12.62]	0.16*** [6.26]	0.71*** [24.04]	0.00*** [6.68]	750
Gasoline	Ener	0.01*** [7.52]	0.01** [2.22]	0.99*** [608.93]	0.00 [0.51]	914
Gold	Prec	0.04*** [14.70]	-0.04*** [-6.11]	0.94*** [307.78]	0.00*** [7.58]	3263
Gold Guinea	Prec	0.06*** [18.97]	-0.04*** [-5.03]	0.91*** [194.87]	0.00*** [8.60]	1973
Gold Mini	Prec	0.04*** [18.77]	-0.04*** [-6.35]	0.93*** [278.32]	0.00*** [9.17]	3263
Gold Petal	Prec	0.11*** [14.71]	-0.11*** [-4.63]	0.83*** [81.16]	0.00*** [7.07]	1072
Heatingoil	Ener	0.05*** [9.47]	0.06*** [12.31]	0.97*** [256.38]	0.00*** [6.39]	1044
Kapaskhali	Agri	9.42*** [29.62]	9.35*** [29.18]	0.00* [1.65]	0.00*** [100.87]	2379

Note: robust tstats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=NonPrecious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious; Cons=constant (intercept) ; Obs= no of Observations.

Table 5.7B: Estimated TGARCH (1,1) model parameters-MCX (contd…)

Variable	Sector	Alpha(α)	Gamma(γ)	Beta(β)	Cons	Obs
Lead	NP	0.04*** [8.07]	0.01 [1.17]	0.96*** [211.82]	0.00** [2.37]	2239
Lead Mini	NP	0.05*** [6.07]	0.02 [1.64]	0.95*** [102.63]	0.00*** [2.65]	1342
Maize	Agri	0.36*** [13.77]	0.08** [2.55]	0.67*** [43.71]	0.00*** [9.08]	898
Menthaoil	Agri	0.23*** [11.41]	-0.18** [-2.47]	0.05*** [3.34]	0.00*** [37.23]	2897
Natural Gas	Ener	0.02*** [3.85]	-0.02*** [-3.28]	0.87*** [15.28]	0.00*** [30.51]	2528
Nickel	NP	0.06*** [9.20]	0.00 [0.52]	0.94*** [182.22]	0.00*** [3.49]	2431
Nickel Mini	NP	0.04*** [3.22]	0.02 [1.21]	0.92*** [41.36]	0.00** [2.07]	857
Pepper	Agri	0.26*** [9.93]	0.08** [2.55]	0.75*** [48.18]	0.00*** [10.20]	1373
Platinum	Prec	0.00*** [12.33]	0.03*** [33.21]	1.00*** [65.46]	0.00*** [144.41]	1155
Refined Soyoil	Agri	0.09*** [8.07]	0.07*** [5.47]	0.86*** [48.55]	0.00*** [6.37]	1386
Rubber	Agri	0.38*** [11.68]	0.25*** [8.96]	0.78*** [52.81]	0.00*** [6.78]	1079
Silver	Prec	0.11*** [16.54]	-0.02*** [-2.61]	0.84*** [99.30]	0.00*** [11.12]	3262
Silver Mini	Prec	0.07*** [14.81]	-0.03*** [-4.37]	0.90*** [160.52]	0.00*** [9.90]	3234
Soybean	Agri	0.11*** [6.54]	0.09*** [4.98]	0.80*** [28.85]	0.00*** [6.09]	823
Thermal Coal	Ener	0.05*** [2.79]	-0.14*** [-3.49]	0.34*** [6.03]	0.00*** [10.57]	886
Tin	NP	0.03*** [7.56]	0.01*** [3.17]	0.98*** [404.24]	0.00*** [6.78]	1518
Turmeric	Agri	0.22*** [4.83]	0.22*** [4.94]	0.02 [0.50]	0.00*** [24.41]	1082
Urad	Agri	0.12*** [6.92]	0.01 [0.59]	0.90*** [109.96]	0.00 [1.39]	788
Wheat	Agri	1.33*** [14.65]	1.09*** [11.00]	0.45*** [28.86]	0.00*** [22.92]	1099
Zinc	NP	0.04*** [9.28]	0.00 [0.50]	0.96*** [252.00]	0.00*** [3.24]	2616
Zinc Mini	NP	0.06*** [5.23]	0.01 [0.86]	0.92*** [70.56]	0.00*** [3.15]	1349

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=NonPrecious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious. Cons=constant (intercept) ; Obs= no of Observations.

Table 5.8A: Estimated TGARCH (1,1) model parameters-NCDEX

Variable-Tgarch	Sector	Alpha(α)	Gamma(γ)	Beta(β)	Cons	Obs
Barley	Agri	0.18***	0.04	0.69***	0.00***	2433
		[8.23]	[1.53]	[33.70]	[10.49]	
Brent Crude Oil	Ener	0.08***	0.02***	0.92***	0.00***	2804
		[11.51]	[2.70]	[173.45]	[9.50]	
Castor Disa	Agri	0.07***	-0.02*	0.88***	0.00***	1557
		[6.77]	[-1.65]	[71.10]	[5.01]	
Castor Seed	Agri	0.06***	-0.02*	0.92***	0.00***	1694
		[5.21]	[-1.93]	[94.41]	[3.57]	
Chana	Agri	0.04***	0.00	0.94***	0.00***	1824
		[4.63]	[0.16]	[88.72]	[2.91]	
Cotton Seed Oilcake	Agri	0.04***	0.01	0.93***	0.00***	1631
		[3.49]	[1.02]	[65.43]	[3.19]	
Cotton Seed Oilcake Akola	Agri	0.03***	0.01	0.93***	0.00***	1448
		[3.20]	[1.30]	[44.99]	[2.62]	
Cotton Seed Oilcake Kadi	Agri	0.12***	-0.08***	0.92***	0.00***	933
		[23.10]	[-7.39]	[992.28]	[6.87]	
Copper before 2010	NP	0.08***	0.05***	0.94***	0.00***	920
		[6.07]	[3.87]	[79.96]	[2.81]	
Copper since 2010	NP	0.09***	0.07***	0.92***	0.00***	1598
		[8.34]	[5.72]	[89.75]	[4.61]	
Crude Oil	Ener	0.06***	0.02***	0.95***	0.00***	2227
		[7.98]	[3.08]	[154.02]	[4.31]	
Dhaniya	Agri	0.10***	0.00	0.85***	0.00***	1920
		[5.02]	[0.01]	[39.74]	[4.96]	
Guar Gum	Agri	0.04***	-0.05***	0.92***	0.00***	2355
		[5.73]	[-6.62]	[115.32]	[6.96]	
Gold Pure Mumbai Kg	Prec	0.02***	-0.04***	0.97***	0.00*	1200
		[3.15]	[-5.71]	[224.44]	[1.83]	
Groundnut Expeller Oil	Agri	0.17***	0.08***	0.89***	0.00***	1212
		[9.64]	[4.45]	[196.47]	[22.54]	
Groundnut(in shell)	Agri	0.12***	-0.06***	0.88***	0.00***	1212
		[12.28]	[-3.67]	[230.65]	[9.65]	
Gold	Prec	0.09***	0.02	0.84***	0.00***	1237
		[14.56]	[1.17]	[64.69]	[12.03]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=NonPrecious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious. Cons=constant (intercept) ; Obs= no of Observations.

Table 5.8B: Estimated TGARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Alpha(α)	Gamma(γ)	Beta(β)	Cons	Obs
Gold 100g Ahmd	Prec	0.02**	-0.09***	0.93***	0.00***	1210
		[2.51]	[-7.65]	[120.47]	[4.66]	
Gur	Agri	0.18***	-0.10**	0.62***	0.00***	860
		[7.09]	[-2.02]	[13.16]	[7.68]	
Gur MZFNR	Agri	0.06***	-0.11***	0.85***	0.00***	2168
		[5.75]	[-9.47]	[64.88]	[7.05]	
Jeera	Agri	0.06***	0.00	0.93***	0.00***	3004
		[8.23]	[0.20]	[124.24]	[4.92]	
Raw Jute	Agri	0.17***	0.10***	0.87***	0.00***	1052
		[7.22]	[4.55]	[83.68]	[12.01]	
V 797 Kapas	Agri	0.07***	0.01	0.88***	0.00***	2539
		[7.39]	[1.06]	[64.89]	[6.19]	
Maize	Agri	0.09***	0.02	0.89***	0.00***	895
		[4.63]	[1.25]	[45.10]	[4.21]	
Yellow/Red Maize	Agri	0.15***	-0.15***	0.77***	0.00***	1753
		[10.08]	[-7.45]	[49.26]	[8.26]	
RM seed oilcake	Agri	0.15***	0.09***	0.92***	0.00***	1203
		[9.98]	[5.48]	[479.50]	[23.72]	
Masoor Bold	Agri	0.21***	0.01	0.85***	0.00***	1280
		[22.63]	[0.43]	[219.19]	[5.10]	
Nickel	NP	0.12***	0.05***	0.92***	0.00***	1270
		[12.29]	[5.05]	[159.38]	[12.53]	
Potato	Agri	0.22***	0.03	0.66***	0.00***	835
		[3.53]	[0.54]	[9.65]	[3.77]	
Polypropylene	Ener	0.49***	0.19***	0.79***	0.00***	897
		[11.21]	[5.08]	[79.15]	[3.70]	
Black Pepper	Agri	0.05***	-0.02**	0.92***	0.00***	2791
		[7.22]	[-2.17]	[125.42]	[5.69]	
PVC	Ener	0.08***	0.04***	0.94***	0.00***	810
		[7.38]	[3.76]	[130.30]	[4.18]	
PVC Mumbai	Ener	0.31***	0.08***	0.83***	0.00***	897
		[10.50]	[2.61]	[112.56]	[4.40]	
RBD Palmolein	Agri	0.04***	0.02***	0.97***	0.00**	880
		[6.16]	[2.95]	[159.94]	[2.26]	
Rubber RSS 4	Agri	0.07***	-0.23***	0.83***	0.00***	1096
		[6.94]	[-10.96]	[141.84]	[28.76]	
RM Oil	Agri	0.17***	0.00	0.83***	0.00***	1306
		[8.86]	[0.08]	[91.55]	[16.36]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=NonPrecious,Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious. Cons=constant (intercept) ; Obs= no of Observations.

Table 5.8C: Estimated TGARCH (1,1) model parameters-NCDEX (contd…)

Variable	Sector	Alpha(α)	Gamma(γ)	Beta(β)	Cons	Obs
RM Seed	Agri	0.08***	0.03**	0.90***	0.00***	1233
		[6.01]	[2.04]	[59.91]	[3.68]	
RM Seed Jaipur	Agri	0.09***	0.00	0.88***	0.00***	2142
		[6.99]	[0.15]	[71.02]	[8.33]	
Soymeal (Indore)	Agri	0.11***	0.00	0.92***	0.00***	1633
		[13.39]	[0.11]	[523.92]	[13.11]	
Soymeal Export	Agri	0.07***	-0.08***	0.93***	0.00***	1356
		[19.55]	[-4.54]	[734.47]	[13.27]	
Shankar Kapas(Rajkot)	Agri	0.08***	0.00	0.88***	0.00***	694
		[6.94]	[0.04]	[91.37]	[10.75]	
Silver	Prec	0.06***	-0.04***	0.89***	0.00***	1237
		[11.09]	[-3.53]	[99.96]	[6.05]	
Silver 5 Kgs Ahmd	Prec	0.03***	-0.06***	0.93***	0.00***	1033
		[3.96]	[-5.21]	[116.18]	[4.02]	
Silver 5 Kgs Delhi	Prec	0.18***	0.05	0.74***	0.00***	894
		[7.40]	[1.25]	[25.97]	[4.96]	
Silver Pure Delhi	Prec	0.02***	-0.05***	0.96***	0.00**	1428
		[8.12]	[-8.22]	[336.76]	[2.22]	
Steel Long (BIS 2830)	NP	0.10***	-0.09***	0.86***	0.00***	1232
		[9.90]	[-4.96]	[83.41]	[4.20]	
Sugar (M Grade)	Agri	0.03***	-0.06***	0.90***[	0.00***	1124
		[3.12]	[-4.79]	72.74]	[5.29]	
Sugar (M Grade) MZFNR	Agri	0.16***	-0.60***	0.40***	0.00***	1070
		[3.90]	[-10.62]	[13.67]	[12.09]	
Soya Bean	Agri	0.15***	0.06***	0.71***	0.00***	3314
		[11.10]	[4.37]	[33.13]	[12.60]	
Soy oilrefined	Agri	0.11***	0.02	0.89***	0.00***	1824
		[7.71]	[1.25]	[71.42]	[4.24]	
Turmeric	Agri	0.09***	0.00	0.89***	0.00***	3162
		[8.65]	[0.10]	[89.33]	[8.36]	
Yellow Peas	Agri	0.21***	-0.05*	0.83***	0.00***	927
		[10.14]	[-1.82]	[137.30]	[11.38]	
Zinc	NP	0.11***	0.03*	0.92***	0.00***	1270
		[11.38]	[1.75]	[301.57]	[16.43]	

Note: robust t-stats are in the brackets; *** p<0.01, ** p<0.05, * p<0.1; NP=NonPrecious, Agri= Agriculture, Envi=Environmental; Ener=Energy; Prec=precious. Cons=constant (intercept) ; Obs= no of Observations.

The second type of GARCH (1,1) model which allows asymmetric (leverage) effects is the Threshold-GARCH (1,1) model. This model divides the distribution of innovations into two disjunctive intervals and then approximates a piecewise linear function for the conditional variance (Glosten et al., 1993). Through the inclusion of lagged conditional variances as a regressor, Zakoian (1994) extended the Threshold model to account for leverage effects. The same model has been employed here.

Form tables 5.7A and 5.7B it is evident that there are leverage effects in the commodity futures which belong to the MCX. The leverage effect is positively significant in the case of Almond, Areca (Jhaji), ATF, Brent Crude, Cardamom, CER, Copper, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Kapaskhali, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Soybean, Tin, Turmeric and Wheat. These commodity futures are pronouncedly affected by bad news (negative shocks), because the indicator value becomes one in these commodity futures since the total news effect will be $\alpha + \gamma$ whenever there is negative news. The unexpected fall in the price of these commodity futures because of bad news increases the predictable volatility more than a same size unexpected increase in price (since positive news impact will be only α) and this leads to a negative relationship between returns and volatility.

On the other hand, in the case of Aluminium, Aluminium Mini, Coriander, Chana, Gold, Gold Guinea, Gold Mini, Gold Petal, Lead, Lead Mini, Mentha oil, Natural Gas, Nickel, Nickel Mini, Silver, Silver Mini, Thermal Coal, Urad, Zinc Mini and Zinc there is no the leverage effect, since the leverage coefficients (γ) in these commodity futures are either statistically insignificant or negatively significant. On an average, the sum of the ARCH and TGARCH ($\alpha + \gamma = 0$) coefficients sum to zero and because of this, either the positive (good) or negative (bad) news does not have any impact on conditional volatility.

On the whole, the TGARCH results are similar to the EGARCH model; however the TGARCH model reports leverage in the case of Areca (Jhaji), Kapaskhali, Soybean, Turmeric and fails in the case of Chana. There is an asymmetric effect in the case of agriculture, energy and environment sectoral commodity futures and no asymmetric effect in the case of precious and nonprecious sectoral commodity futures. Similar to the EGARCH model, in most of the commodity futures the symmetric effect dominates the asymmetric effect in these commodity futures. The leverage effect is significant in the case of agriculture, energy and environment,

making precious and nonprecious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange.

From tables 5.8A, 5.8B and 5.8C it is evident that there are leverage effects in the commodity futures which belong to the NCDEX. The leverage effect is positively significant in the case of Brent Crude, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, Rape Mustard seed oilcake, Nickel, Polypropylene, both the polyvinyl chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soya Bean, and Zinc. These commodity futures are pronouncedly affected by bad news (negative shocks), because the indicator value becomes one in these commodity futures since the total news effect will be $\alpha + \gamma$ whenever there is negative news. The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price (since the positive news impact will be only α) and this leads to a negative relationship between returns and volatility.

On the other hand, in the case of Barley, Castor (Disa), Castor Seed, Chana, Cotton Seed Oilcake, Cotton Seed Oilcake Akola, Cotton Seed Oilcake Kadi, Dhaniya, Guar Gum, Gold Pure Mumbai Kg, Groundnut (in shell), Gold, Gold 100g (Ahmadabad), Gur, Gur (Muzzafer Nagar), Jeera, V 797 Kapas, Maize, Yellow/Red Maize, Masoor Bold, Black Pepper, Rubber RSS 4, Rape Mustard Oil, Rape Mustard (Jaipur), Soymeal (Indore), Soymeal Export, Shankar Kapas(Rajkot), Silver, Silver 5 KGS (Ahmadabad), Silver (Delhi), Silver Pure Delhi, Steel Long (BIS 2830), Sugar (M Grade), Sugar M Grade (Muzzafer Nagar), Soy oil refined, Turmeric and Yellow Peas, there is no leverage effect, since the leverage coefficients (γ) in these commodity futures are either statistically insignificant or negatively significant. On an average the sum of the ARCH and TGARCH ($\alpha + \gamma = 0$) coefficients sum to zero and because of this, either the positive (good) or negative (bad) news does not have any impact on conditional volatility.

On the whole, the TGARCH results are similar to the EGARCH model; however the TGARCH model reports the leverage in the case of Brent Crude and Nickel and fails in the case of Cotton Seed Oilcake Kadi, V 797 Kapas, Soymeal (Indore) and Shankar Kapas (Rajkot). There is an asymmetric effect in the case of agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect only in the case of precious sectoral commodity futures. Similar to the EGARCH model, in most of the commodity futures, the symmetric effect dominates the asymmetric effect in these commodity futures. The leverage effect is significant in the case of

agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect is found only in the case of precious sectoral commodity futures.

5.5: Assessing Model Fit

Using two symmetric GARCH (namely GARCH (1,1) and IGARCH (1,1)) models and two asymmetric GARCH (namely EGARCH (1,1) and TGARCH (1,1)) models , we have analyzed the commodity futures volatility in this chapter. The obvious question that arises in this context is which model better explains commodity futures volatility during the sample period. To address this question, following the literature we choose the AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion), which are both methods of assessing model fit. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are a way of selecting the best model from a set of models. The preferred model is the one with the minimum AIC and BIC values.

From tables 5.9A and 5.9B of the MCX exchange commodity futures and tables 5.10A and 5.10B of the NCDEX exchange commodity futures, it is evident that there is no clear pattern from the estimated AIC and BIC coefficients to choose the minimum values of AIC and BIC. In most of the cases the minimum values of AIC and BIC are commodity futures specific and not even sector specific. Hence we have adopted the majority criteria that where the model yields the minimum AIC and BIC values for most commodity futures cases. Thus, we find that the EGARCH (1,1) model is the best fit model for the MCX exchange and GARCH (1,1) model is the best fit model for the NCDEX exchange.

Table 5.9A: Model wise estimated AIC and BIC values of the MCX Exchange

Commodity/ Model	GARCH		IGARCH		EGARCH		TGARCH	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
Almond	-5843	-5824	-5830	-5816	-5884	-5859	-5863	-5839
Aluminium	-7024	-7004	-7012	-6997	-7029	-7004	-7023	-6998
Aluminium Mini	-15716	-15692	-15703	-15685	-15710	-15681	-15714	-15684
Areca Jhaji	-5627	-5607	-5628	-5613	-5658	-5634	-5626	-5601
ATF	-7849	-7828	-7846	-7831	-7843	-7818	-7863	-7838
Brent Crude	-7732	-7711	-7710	-7694	-7737	-7712	-7766	-7740
Cardamom	-10897	-10874	-10896	-10878	-11098	-11069	-11147	-11118
CER	-5839	-5820	-5839	-5824	-5865	-5840	-5869	-5844
Chana	-6460	-6439	-6460	-6445	-6300	-6295	-6458	-6433
Copper Mini	-5523	-5504	-5514	-5500	-5524	-5500	-5486	-5481
Coriander	-7485	-7464	-7416	-7401	-7489	-7463	-7486	-7460
Cotton	-5664	-5645	-5622	-5607	-5675	-5650	-5665	-5641
CPO	-12286	-12264	-12286	-12269	-12285	-12257	-12297	-12269
Crudeoil	-16057	-16033	-16049	-16031	-16065	-16035	-16070	-16040
Flake Menthol	-4283	-4265	-4281	-4267	-4303	-4280	-4292	-4268
Gasoline	-5272	-5253	-5272	-5258	-5288	-5264	-5272	-5248
Gold	-21499	-21475	-21495	-21477	-21527	-21497	-21516	-21485
Gold Guinea	-12879	-12856	-12878	-12861	-12877	-12849	-12888	-12860
Gold Mini	-21483	-21458	-21479	-21461	-21506	-21475	-21502	-21472
Gold Petal	-6980	-6960	-6980	-6965	-6997	-6972	-6990	-6965
Heatingoil	-5872	-5852	-5868	-5853	-5921	-5897	-5878	-5854
Kapaskhali	-11533	-11510	-11125	-11108	-11768	-11739	-12056	-12027

Note: Coefficients highlighted with grey color indicate the minimum AIC and BIC values among all the four models.

Table 5.9B: Model wise estimated AIC and BIC values of the MCX Exchange (contd…)

Commodity/Model	GARCH		IGARCH		EGARCH		TGARCH	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
Lead	-11796	-11773	-11797	-11779	-11794	-11766	-11794	-11766
Lead Mini	-7795	-7774	-7792	-7777	-7795	-7769	-7795	-7769
Maize	-6009	-5990	-6011	-5997	-6028	-6004	-6009	-5985
Menthaoil	-12050	-12026	-11927	-11909	-11599	-11569	-12055	-12025
Natural Gas	-11319	-11295	-11314	-11296	-11018	-10989	-11011	-10982
Nickel	-12638	-12615	-12638	-12621	-12625	-12596	-12636	-12607
Nickel Mini	-5066	-5047	-5061	-5047	-5067	-5043	-5065	-5041
Pepper	-7048	-7027	-7044	-7028	-7068	-7042	-7049	-7023
Platinum	-5878	-5858	-5637	-5622	-5651	-5626	-5312	-5287
Refined Soyoil	-8788	-8767	-8772	-8757	-8795	-8769	-8793	-8767
Rubber	-7253	-7233	-7253	-7238	-7326	-7301	-7302	-7277
Silver	-18047	-18017	-18008	-17990	-18047	-18017	-18035	-18004
Silver Mini	-18092	-18068	-18076	-18058	-18106	-18076	-18096	-18065
Soyabean	-5080	-5061	-5072	-5058	-5069	-5045	-5084	-5060
Thermal Coal	-5586	-5567	-5536	-5521	-5596	-5572	-5589	-5565
Tin	-8125	-8104	-8120	-8104	-8043	-8016	-8125	-8099
Turmeric	-4905	-4886	-4859	-4844	-4900	-4875	-4890	-4865
Urad	-3875	-3856	-3871	-3857	-3898	-3874	-3873	-3849
Wheat	-7207	-7187	-7207	-7192	-7252	-7227	-7241	-7216
Zinc	-14190	-14166	-14190	-14173	-13544	-13514	-14188	-14158
Zinc Mini	-8134	-8113	-8128	-8113	-8134	-8108	-8132	-8106

Note: Coefficients highlighted with grey color indicate the minimum AIC and BIC values among all the four models.

Table 5.10A: Model wise estimated AIC and BIC values of the NCDEX Exchange

Commodity/ Model	GARCH		IGARCH		EGARCH		TGARCH	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
Barley	-14671	-14648	-14633	-14616	-14289	-14260	-14671	-14642
Brent Crude Oil	-15314	-15291	-15310	-15292	-15254	-15225	-15314	-15285
Castord	-10120	-10099	-10106	-10090	-10116	-10089	-10119	-10093
Castor Seed	-9792	-9770	-9790	-9774	-9798	-9771	-9793	-9765
Chana	-10760	-10738	-10752	-10736	-10751	-10723	-10758	-10730
Cotton Seed Oilcake	-9718	-9697	-9708	-9692	-9611	-9584	-9717	-9690
Cotton Seed Oilcake Akola	-8668	-8647	-8655	-8640	-8672	-8646	-8668	-8641
Cotton Seed Oilcake Kadi	-7621	-7606	-7500	-7490	-7598	-7574	-7621	-7601
Copper before 2010	-4838	-4819	-4834	-4819	-4841	-4817	-4846	-4821
Copper since 2010	-9993	-9972	-9982	-9965	-10005	-9978	-10007	-9980
Crude Oil	-9315	-9294	-9290	-9274	-9209	-9183	-9031	-9025
Dhaniya	-10250	-10228	-10227	-10210	-10246	-10218	-10248	-10220
Guar Gum	-12324	-12301	-12310	-12293	-12330	-12301	-12340	-12311
Gold Pure Mumbai Kg	-7677	-7657	-7679	-7663	-7698	-7673	-7688	-7662
Groundnut Expeller Oil	-8426	-8405	-8425	-8410	-8794	-8769	-8432	-8407
Groundnut(in shell)	-9928	-9907	-9911	-9896	-9863	-9837	-9929	-9903
Gold	-8417	-8396	-8383	-8368	-8373	-8348	-8415	-8390
Gold 100 Grams Ahmd	-8315	-8295	-8311	-8296	-8322	-8297	-8344	-8318
Gur	-5625	-5606	-5608	-5593	-5605	-5581	-5625	-5601
Gur Muzaffarnagar	-13981	-13958	-13963	-13946	-14014	-13985	-14009	-13980
Jeera	-16911	-16887	-16901	-16883	-16909	-16879	-16909	-16879
Raw Jute	-6967	-6947	-6968	-6953	-7019	-6994	-6980	-6955
V 797 Kapas	-15463	-15440	-15434	-15417	-15159	-15130	-15462	-15433
Maize	-5543	-5524	-5532	-5518	-5526	-5502	-5542	-5518
Yellow/Red Maize	-11160	-11138	-11162	-11145	-11192	-11165	-11161	-11134
RM seed oilcake	-10018	-10003	-10011	-10001	-10055	-10029	-10034	-10013
Masoor Bold	-9267	-9251	-9218	-9208	-9231	-9205	-9265	-9244
Nickel	-6325	-6304	-6321	-6305	-5847	-5821	-6328	-6302

Note: Coefficients highlighted with grey color indicate the minimum AIC and BIC values among all the four models.

Table 5.10B: Model wise estimated AIC and BIC values of NCDEX Exchange (contd…)

Commodity/ Model	GARCH		IGARCH		EGARCH		TGARCH	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
Potato	-4365	-4346	-4347	-4332	-4364	-4340	-4363	-4340
Polypropylene	-7109	-7095	-7015	-7005	-7074	-7050	-7118	-7099
Black Pepper	-15628	-15604	-15622	-15604	-15631	-15601	-15630	-15600
PVC	-5128	-5110	-5129	-5115	-5128	-5105	-5132	-5109
PVC - Mumbai	-5919	-5900	-5856	-5842	-5904	-5880	-5920	-5896
RBD Palmolein	-5804	-5785	-5805	-5791	-5797	-5773	-5807	-5783
Rubber RSS 4	-7517	-7497	-7515	-7500	-7520	-7495	-7542	-7517
RM Oil	-10727	-10706	-10971	-10961	-10987	-10961	-10725	-10699
RM Seed	-7985	-7965	-7975	-7960	-7891	-7865	-7986	-7960
Rape Mustard Seed	-14228	-14205	-14206	-14189	-14211	-14182	-14226	-14198
Soymeal (Indore)	-11593	-11576	-11562	-11551	-11512	-11485	-11591	-11569
Soyameal Export	-12301	-12285	-12241	-12231	-8981	-8955	-12308	-12287
Shankar Kapas(Rajkot)	-4628	-4610	-4618	-4604	-4606	-4583	-4626	-4603
Silver 5 Kgs Ahmedabad	-5643	-5623	-5636	-5621	-5654	-5629	-5651	-5627
Silver 5 Kgs	-5222	-5203	-5220	-5205	-5231	-5207	-5221	-5198
Silver	-6903	-6883	-6898	-6883	-6905	-6879	-6908	-6882
Silver 5 Kgs Ahmd before 2008	-8215	-8194	-8217	-8201	-8236	-8210	-8238	-8212
Steel Long (BIS 2830)	-7690	-7669	-7692	-7676	-7690	-7664	-7698	-7672
Sugar (M Grade)	-7712	-7692	-7705	-7690	-7725	-7700	-7721	-7695
Sugar (M Grade) MZFNR	-7112	-7092	-7109	-7094	-7144	-7119	-7141	-7117
Soya Bean	-19913	-19888	-19882	-19864	-19793	-19763	-19888	-19857
Soy oil-refined	-12191	-12169	-12187	-12171	-12170	-12143	-12190	-12162
Turmeric	-16984	-16960	-16964	-16946	-16973	-16943	-16983	-16952
Wheat	-8470	-8449	-8466	-8451	-8361	-8336	-8468	-8442
Yellow Peas	-7062	-7043	-7042	-7027	-5627	-5603	-7061	-7037
Zinc	-6781	-6760	-6770	-6754	-6771	-6746	-6780	-6755

Note: Coefficients highlighted with grey color indicate the minimum AIC and BIC values among all the four models.

5.6: Conclusion

We know from the previous chapters (two, three and four) that Indian commodity futures markets are the next best alternative to equity markets for investment in India, there exists a tradeoff between the risk and return and that the traditional capital asset pricing model succinctly explains the relationship between risk and return. We also know that approximately forty five percent of the commodity futures can be perfectly hedged against inflation components such as expected and unexpected inflation. Given such a clear understanding in the previous chapters about the Indian commodity futures as an investible class of assets, it enhances the understanding more if we include the volatility analysis from various perspectives (investor, regulator, producer and end user). Hence we proceeded with the two symmetric GARCH (namely GARCH (1,1) and IGARCH (1,1)) models and two asymmetric GARCH (namely EGARCH (1,1) and TGARCH (1,1)) models to account for the positive and negative shocks on these commodity futures using the daily data of the Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) exchanges commodity futures contracts from January 2004 to December 2014.

The GARCH (1,1) analysis indicates that all the commodity futures of the MCX and NCDEX contracts coefficients (ARCH (α) and GARCH (β)) are positive and statistically significant except Cotton and Kapashkhali futures contracts of the MCX. The ARCH coefficients for the MCX range from 0.00 to 0.64 and the average turns out to be 0.13. Similarly, the NCDEX coefficients range from 0.02 to 0.40 and the average turns out to be 0.10. On the other hand, the GARCH coefficients of the MCX range from 0.00 to 0.99 and the average turns out to be 0.78 and the ARCH coefficients range from 0.48 to 0.97 and the average turns out to be 0.86. The MCX exchange average sum of the α+β is 0.90 and NCDEX exchange sum is 0.97. In most of the commodity futures of the MCX and NCDEX, the sum of $\alpha + \beta \approx 1$, which indicates that the underlying GARCH process is integrated. The mean of the estimated half-life value of the MCX exchange is 42.87 days, which means it takes 42.87 days on an average on the MCX exchange for a shock to volatility to diminish to half its original size. Similarly, the estimated half-life value of the NCDEX exchange is 43.89 days, which means it takes 43.89 days on an average on the NCDEX exchange for a shock to volatility to diminish to half its original size. On the other hand, the average mean lag of the MCX is 14 days and NCDEX is 10 days for shocks to come

through in the model. So, both the exchanges (MCX and NCDEX) pass through the GARCH (1,1) constraints and it is also true that in both the exchanges, the conditional variance displays more autoregressive persistence (evident from the GARCH, mean lag and half-life value coefficients) because volatility reacts more intensively to market movements. Persistence of the shocks (evident from the GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures. Rather they are present in all the sectors.

From the GARCH (1,1) analysis, we have noted that for many of the commodity futures of the MCX and NCDEX, the GARCH coefficients sum is approximately unity, which indicates that the underlying GARCH process is integrated. Accordingly, we have employed the IGARCH (1,1) model and the results indicate that All the commodity futures of the MCX and NCDEX are positive and statistically significant and also they sum to unity. Commodity futures contracts such as Cardamom, Coriander, Cotton, Kapaskhali, Mentha oil, Thermal Coal and Turmeric of MCX and Raw Jute and Sugar M grade (Muzzaffer Nagar) of the NCDEX possess larger α coefficients compared to β coefficients, which means that recent news influences these commodity futures price changes to a greater extent than older news and we can say that the shocks are more pronounced in the subsequent periods. All other commodity futures other than the above said, possess larger β (persistence) coefficients compared to (news) α coefficients, which means that the older news influences these commodity futures price changes rather than recent news, hence their conditional variance displays more autoregressive persistence. The parameters of the IGARCH (1,1) model are very close to the GARCH (1,1) model in most of the commodity futures. All the commodity futures of the MCX and NCDEX's intercepts are zero and statistically significant. This phenomenon indicates that the volatility forecasts are simply $\sigma_h^2(1)$ for all forecast horizons. The estimated IGARCH model parameters for all the commodity futures of the MCX and NCDEX exhibit persistence in variance, which means that current information remains important for the forecasts of conditional variance for all horizons in all these commodity futures irrespective of the sector to which they belong. Thus, today's information is very crucial for forecasting into the future. Similarly, shocks are permanent to the system and these shocks to the conditional variance will never die out due to the persistence phenomenon.

The GARCH (1,1) model enforces a symmetric response of volatility to positive and negative news (shocks). However, a negative shock to the return series is likely to increase volatility more than a positive shock of the same magnitude (Black, 1976) and this phenomenon is known as the leverage effect. To overcome the asymmetry problem in the GARCH models, Nelson (1991) proposes the Exponential GARCH model, which allows asymmetric effects between the positive and negative return series. In order to capture the asymmetric volatility effects, we have also employed the asymmetric GARCH models.

The leverage effect is negatively significant in the case of Almond, ATF, Brent Crude, Cardamom, CER, Chana, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Tin, and Wheat of the MCX exchange and Cotton Seed Oilcake Kadi, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, V 797 Kapas, Rape Mustard seed oilcake, Polypropylene, both the Poly Vinyl Chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soymeal (Indore), Shankar Kapas (Rajkot), Soya Bean and Zinc of the NCDEX exchange. These commodity futures are markedly affected by bad news (negative shocks). The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this leads to a negative relationship between returns and volatility. There is an asymmetric effect in the case of agriculture, energy and environmental sectoral commodity futures and no asymmetric effect in the case of precious and non-precious sectoral commodity futures of the MCX exchange. Similarly, the asymmetric effect is present only in the case of agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect is found only in the case of precious sectoral commodity futures. The absence of asymmetric effects makes the precious and non-precious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange and only precious commodity futures the better investment on the NCDEX exchange.

The second type of GARCH (1,1) model which allows asymmetric (leverage) effects is the Threshold-GARCH (1,1) model, which divides the distribution of innovations into two disjunctive intervals and then approximates a piece wise linear function for the conditional variance (Glosten et al, (1993); Zakoian (1994)). In order to have a better understanding of this asymmetric volatility we have also employed the TGARCH (1,1) and the results indicate that the

leverage effect is positively significant in the case of Almond, Areca (Jhaji), ATF, Brent Crude, Cardamom, CER, Copper, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Kapaskhali, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Soybean, Tin, Turmeric and Wheat of MCX exchange and Brent Crude, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, Rape Mustard seed oilcake, Nickel, Polypropylene, both the polyvinyl chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soya Bean, and Zinc of NCDEX exchange. These commodity futures are markedly affected by bad news (negative shocks), because the indicator value becomes one in these commodity futures since the total news effect will be $\alpha + \gamma$ whenever there is negative news. The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price (since the impact of positive news will only be α) and this leads to a negative relationship between returns and volatility. On an average, the estimated TGARCH results are similar (not in terms of magnitude, but in terms of sign) to the EGARCH model. Once again the leverage effect is significant in the case of agriculture, energy and environment, making precious and nonprecious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange and only precious commodity futures the better investment on the NCDEX exchange.

We have analyzed the volatility of the Indian Commodity futures using two symmetric GARCH (namely GARCH (1,1) and IGARCH (1,1)) models and two asymmetric GARCH (namely EGARCH (1,1) and TGARCH (1,1)) models. The obvious question that arises in this context is which model better explains commodity futures volatility during the sample period? To address this question, we have estimated the AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) values. The preferred model is the one with the minimum AIC and BIC values. From the estimated AIC and BIC values of the MCX and NCDEX exchange commodity futures, it is evident that there is no clear pattern to choose the minimum values of AIC and BIC. In most of the cases the minimum values of AIC and BIC are commodity futures specific and not even sector specific. Hence we have gone by the majority criteria where the model yields minimum AIC and BIC values for most commodity futures cases. Thus, it emerges that the EGARCH (1,1) model is the best fit model for the MCX exchange and GARCH (1,1) model is the best fit model for the NCDEX exchange.

On the whole, volatility analysis indicates that in most of the commodity futures of the MCX and NCDEX, the sum of ARCH and GARCH coefficients is one ($\alpha + \beta \approx 1$), which indicates that the underlying GARCH process is integrated. On an average on the MCX exchange, it takes 43 (estimated half-life value) days for a shock to volatility to diminish and on the other hand, it takes 44 days for a shock to volatility to diminish on NCDEX. All the commodity futures contracts (of MCX and NCDEX) conditional variance display more autoregressive persistence (evident from the GARCH, mean lag and half-life value coefficients) because volatility reacts more intensively to market movements. Persistence of the shocks (evident from the GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures. Rather they are present in all the sectors. Commodity futures contracts such as Cardamom, Coriander, Cotton, Kapaskhali, Mentha oil, Thermal Coal and Turmeric of MCX and Raw Jute and Sugar M grade (Muzaffar Nagar) of the NCDEX possess larger ARCH (α) coefficients compared to GARCH (β) coefficients, which means that recent news influences these commodity futures price changes to a greater extent than the older news and we can say that the shocks are more pronounced in the subsequent periods. All other commodity futures other than the above said, possess larger β (persistence) coefficients compared to (news) α coefficients, which means that the older news influences these commodity futures price changes rather than recent news, hence their conditional variance displays more autoregressive persistence. The estimated IGARCH model parameters for all the commodity futures of the MCX and NCDEX exhibit persistence in variance, which means that current information remains important for the forecasts of conditional variance for all horizons in all these commodity futures irrespective of the sector to which they belong. Thus, today's information is very crucial for forecasting into the future. Similarly, shocks are permanent to the system and these shocks to the conditional variance will never die out due to the persistence phenomenon.

The leverage effect (a negative shock to the return series is likely to increase volatility more than a positive shock of the same magnitude) is negatively significant in the case of Almond, ATF, Brent Crude, Cardamom, CER, Chana, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Tin and Wheat of the MCX exchange and Cotton Seed Oilcake Kadi, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, V 797 Kapas, Rape Mustard seed oilcake, Polypropylene, both the Poly Vinyl Chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soymeal

(Indore), Shankar Kapas (Rajkot), Soya Bean and Zinc of the NCDEX exchange. These commodity futures are markedly affected by bad news (negative shocks). The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this lead to a negative relationship between returns and volatility. There is an asymmetric (positive and negative shocks increase future volatility, but a negative shock has a larger effect than does a positive shock) effect in the case of agriculture, energy and environmental sectoral commodity futures and no asymmetric effect in the case of precious and non-precious sectoral commodity futures of the MCX exchange. Similarly, the asymmetric effect is present only in the case of agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect is found only in the case of precious sectoral commodity futures. The absence of asymmetric effects makes the precious and non-precious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange and only precious commodity futures the better investment on the NCDEX exchange.

The following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation, are such as Cardamom, Chana, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Refined Soyoil, Rubber and Tin's leverage effect is negative and significant. Similarly, the NCDEX's commodities such as Cotton Seed Oilcake Kadi, Copper since 2010, Groundnut Expeller Oil, Polypropylene, PVC, RM Seed, RM seed oilcake, Shankar Kapas (Rajkot), Soya Bean and Zinc's leverage effect is also negative and significant. The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this leads to a negative relationship between returns and volatility.

CHAPTER 6

SUMMARY, MAIN FINDINGS AND CONCLUDING REMARKS

6.1: Introduction

Although the first recorded instance of futures trading may be traced to the Dojima Rice futures contracts in 17th Century Japan, formal and standardized commodity futures trading started with the establishment of the Chicago Board of Trade (1848). Commodities have been emerging as an increasingly important class of assets for institutional and individual investors in recent years. Systematic investigation of commodities as an investable asset class goes back at least some 35 years ago (Greer, 1978, Bodie and Rosansky, 1980). However, investing in commodities through futures markets has gained importance ever since the burst of the dot-com bubble. Stung by huge losses, financial investors were on the lookout for a new asset class to diversify their portfolio and reduce their risks. Also in the wake of globalization and surge in global uncertainties, financial organizations around the world were seeking methods and instruments to contain the price risk that these uncertainties bring. Commodity derivatives instruments offered the features that these investors and institutions were looking for in the market (Erb and Harvey 2006; Gordon and Rouwenhorst, 2006). They have been devised to manage price risk by valuing the price of a security based on the value of an underlying commodity. During the past two decades, many institutional portfolio managers added commodity derivatives as an asset class to their portfolios. This resulted in a substantial growth in the use of commodity derivatives that was considerably out of proportion with the historical levels associated with commercial hedging.

Similarly, trading in commodity derivatives in India dates back to 1875, where the Cotton Trade Association began futures trading. The first organized futures market, for various types of cotton appeared in 1921 and subsequently proliferated all over India. Regulated trading in commodities started after the enactment of the Forward Contract (Regulation) Act 1952, which provided the legal framework for organized forward trading in the country and for the recognition of

commodity exchanges. Severe drought and commodity market manipulations in the 1960s led to a ban on commodity forwarding trading in India which lasted till early 2003. Due to the liberalization (World Bank and United Nations Conference on Trade and Development (UNCTAD)) pressures, based on the Kabra and Guru committee's recommendations and the national agricultural policy's (2000) favourable views on commodity futures trading, the Indian government lifted the ban on agricultural commodities and allowed trading in 54 commodities by setting up commodity futures exchanges in 2003 with the aim of creating a common integrated and regulated commodity futures market to enable producers (especially farmers) as well as the end users to hedge the price risk arising out of price fluctuations. However, the recent (2008) ban on four commodities (because people perceived that trading in chickpea, potato, rubber and soy oil aggravated the prices), the recent scandals (such as the Guar futures scandal, 2012 and the NSEL payment scam, 2013) and on one hand illiquidity in some commodities and on the other, huge trading activity only in few bullion, metals and agricultural markets have raised many questions on their fundamental nature as an asset class. On the other hand, recently commodity futures markets have been identified as an investable class of assets in the advanced economies because of their zero or negative correlation with stocks and bonds, the existence of a positive risk premium, their ability to act as the best hedge against rising inflation and their risk reduction capability when added to a portfolio of stocks and bonds. All these perceived benefits of commodity futures as an investable class of assets in the advanced countries also raises questions about whether these benefits will be realized in the Indian context or not, given their one decadal trading history in India.

The present study examines the above raised question in a broader way as whether the Indian commodity futures qualifies as an investable class of asset or not given the investable class of asset advantages especially in the Indian context. The analysis carried out in two stages. In first stage we establish that Indian commodity futures are investable class of assets using equally weighted index. In the second stage, we examine the same questions at commodity level to ascertain the same results that we established at the index level.

6.2: Methodology

This study utilizes all the commodity futures contracts data which are traded on Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX)

between January 2004 to December 2014. The reason to focus only on these two exchanges out of 21 exchanges is that around 97 percent of the trading activity is happening only in these two exchanges. Most of the contracts started trading from January 2004 only.

Equally weighted return index is constructed to study properties of commodity futures as an asset class. Using consumption and traditional capital asset pricing models (C-CAPM and CAPM) we analyze the risk-return relationship. Using the regression techniques, we explore the hedging effectiveness of commodity futures against inflation and its components (expected and unexpected inflation). To better understand the volatility behavior in commodity futures, we employ the symmetric and asymmetric GARCH models.

6.3: Main Findings

Major findings of the study are as follows.

i) The first and foremost objective of the thesis is to assess the short and long-term properties of Indian commodity futures as an investable class of asset in India. The results show that the equally weighted rebalanced nominal (not adjusted for inflation) and real (adjusted for inflation) commodity futures index returns are lower than the equity index and this gap increases as we change the frequency from monthly (approximately 3 percent) to quarterly (approximately 5.5 percent) and then to yearly (approximately 5 percent). On the other hand, the equally weighed index is outperforming the bonds (by 11 percent, 9 percent and 11 percent monthly, quarterly and yearly respectively), Treasury bills (by 9 percent, 8 percent and 9 percent monthly, quarterly and yearly respectively) and inflation (by 9 percent, 11 percent and 13 percent monthly, quarterly and yearly respectively). The performance of the commercially available commodity futures indexes (such as MCX's Comdex, Agriculture, Energy and Metal) other than Dhaanya, are similar to the equally weighted commodity futures index compared to other asset classes. Where, Dhaanya index is yielding higher returns than the equally weighted index as well as equity also. However, these commercially available commodity futures indexes' returns are far below from the equally weighted commodity futures index in all three frequencies. Equally weighted commodity futures which are constructed based on all contracts are found to be yielding higher returns in terms of nominal as well as real returns compared to indexes which are constructed using contracts which survived until December 2014 (on an average the difference is

approximately 1 percent). On an average the qually weighted commodity futures returns (irrespective of the re-balancing frequency) are lower than the equities but higher than bonds, Treasury bills and inflation. However, they are found to be offering the highest (based on Sharpe ratios) risk adjusted returns for the sample period in all three re-balancing frequencies. Compared to the quarterly re-balancing frequency (holding period), monthly and yearly re-balanced commodity futures yield higher returns and this is true in both types of equally weighted indexes. On the other hand, monthly first type (which includes all the futures contracts) equally weighted index is offering higher returns compared to yearly but this relationship is opposite in the case of the second type (which includes only the contracts which survived until December 2014) of equally weighted index. The gap between the two types of equally weighted commodity futures indexes shows that there is a survivor and exclusion bias in the Indian commodity futures markets and rebalancing frequencies does matter a lot.

It is also true that there exists a positive risk premium in the commodity futures, which is also statistically significant. This means, commodity futures are offering more returns than the risk free rate. The commodity futures risk premium is lower (on an average 4 percent) than the equity but much higher than bonds (on an average five to ten times). Though commodity futures are offering lower risk premium and risk adjusted returns (Sharpe ratios) compared to equity but they have a lower standard deviation. This means, though equity might be offering higher returns compared to commodity futures, they are too risky. On an average, commodity futures are offering positive returns most of the time, when compared to equity and bonds.

Though equities are yielding higher returns than commodity futures, their standard deviations are also much higher. This is true in all three re-balancing frequencies. In terms of skewness, the commodity futures returns are negatively distributed at the monthly and quarterly frequency whereas at the yearly frequency the direction is opposite (i.e. changed into positive direction). On the other hand, equity returns are negatively distributed in the case of monthly and yearly frequencies but positively distributed at the quarterly frequency. This indicates that in the case of positive skewness, returns have more weight in the right tails whereas, in the case of negative skewness, returns have more weight in the left tails. Similarly, on an average, for all the assets class indexes kurtosis is less than 3 (except the quarterly Dhaanya index and yearly EWI1). This

indicates that the probability for extreme returns is less than that for a normal distribution and the returns are widely spread around the mean.

It is also evident that commodity futures returns are positively correlated with equity returns. The positive correlation between commodity futures and equity becomes stronger as we change the re-balancing frequency from monthly to quarterly and then to yearly. Contrary to equity, commodity futures are negatively correlated with bonds. The negative correlation between commodity futures and bonds is also statistically significant and it becomes weaker as the re-balancing frequency changes from monthly to quarterly and then to yearly. The negative correlation between commodity futures and bonds leads to better portfolio diversification. At times when either one of the asset classes is generating negative returns, simultaneously, the other asset class provides positive returns, hence on an average, the investor will be safe. The correlation between commodity futures and inflation is not in one direction. As the holding period changes from the monthly to quarterly and then to yearly frequency, commodity futures sensitivity to inflation and to its components (such as changes in inflation and unexpected inflation) switches from the positive to the negative regime and then falls back to the positive regime. However, equities and bonds continue to be negatively sensitive to changes to inflation and unexpected inflation, irrespective of the holding period. Since inflation is persistent over time, unexpected inflation often causes market participants to revise their estimates of future expected inflation in order to maintain the purchasing power of their returns. Revisions about future inflationary expectations have a positive influence on commodity futures but negative influence on equities and bonds. On the whole, commodity futures have an opposite exposure in the monthly and yearly but the same exposure in the case of quarterly frequencies. So, the commodity futures are a better hedge against inflation given the changes in the inflation components.

Commodity wise analysis indicates that on an average the MCX's commodities such as Brent Crude, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapas, Menthaoil, Rubber, Tin, Turmeric and Urad are offering higher returns than the equity, bonds, Treasury bills and inflation. Whereas Almond, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapaskhali, Lead, Lead Mini, Maize, Pepper, Refined Soyoil, Silver, Silver Mini, Soya bean, Thermal Coal, Wheat and Zinc Mini are offering higher returns than bonds, Treasury

bills and inflation. On the other hand, Nickel, Aluminium Mini, Gold Petal and Zinc are yielding higher returns than bonds and inflation, while, ATF's returns are marginally higher than Treasury bills. Whereas commodities such as Aluminium, Areca Nut (Jhaji), CER, Copper Mini, Coriander, Cotton, CPO, Gold Petal (Delhi), Natural Gas, Nickel Mini, Platinum, Silver Micro, Sugar Mini (Kolkata) are not beating any of the traditional asset classes.

Similarly, NCDEX's commodity wise analysis indicates that on an average commodities such as Black Pepper, Chilli LCA334, Cotton Seed Oil cake Akola, Furnace oil, Gold100Grams, Gold Pure Mumbai Kg, Guar Gum, Masoor Bold, Potato, Raw Jute, RM seed oilcake, Silver 5Kg (Ahmedabad) before 2008, Silver 5Kgs (Ahmedabad), Soymeal (Indore) and Turmeric are offering higher returns than the equity, bonds, Treasury bills and inflation. On the other hand, Barley, Castor Seed, Copper before 2010, Cotton Seed Oilcake, Cotton Seed Oil cake (Kadi), Dhaniya, Groundnut (in shell), Ground nut Expeller Oil, Gur, Gur (Muzaffar Nagar), Jeera, Jute Sacking, Medium Staple Cotton, Polypropylene, RM Oil, RM Seed, Sesame Seed, Silver 5Kgs, Soya Bean, Soya meal Export, V797Kapas, Wheat, Yellow/Red Maize and Yellow Peas are offering higher returns than bonds, Treasury bills and inflation. Whereas Brent Crude Oil, Castor, Chana, Coppersince2010, Crude Oil, Gold, PVC, PVC-Mumbai, Shankar Kapas (Rajkot) and Zinc are yielding higher returns than bonds and inflation. Whereas commodities such as Castor, Nickel, RBD Palmolein, Rubber New, Rubber RSS 4, Silver, Soy oil-refined, Steel Long, Steel Long (BIS 2830), Sugar (M Grade), Sugar (M Grade- Kolkata), Sugar (M Grade-Muzaffar Nagar) are not beating any of the traditional asset classes such as equity, bonds, Treasury bills and inflation. It is evident that on an average agricultural and energy products are offering much better returns on the MCX exchange and whereas in the case of NCDEX, precious metals and agricultural commodity contracts are offering much better returns compare to other sectoral commodity futures. In terms of returns holding, quarterly frequency offers highest returns and then followed by monthly and yearly.

ii) The second objective that is examined relates to the risk return relationship in Indian commodity futures during the sample using modified traditional capital asset pricing model (CAPM) and consumption capital asset pricing model (C-CAPM) models. Through the capital asset pricing model literature, it is well established that assets with higher betas (i.e. higher systematic risk) earn higher average returns compared to those with lower (market as well as

consumption) betas. Based on similar logic, for India we examine the exchange wise cross section and time series properties of commodity futures returns to determine whether a similar positive relationship exists in the Indian commodity futures markets or not for the period January 2004 to December 2014.

Exchange –wise (i.e. MCX, NCDEX and a combination of these two) cross section market and consumption beta analysis indicate that there exists is a positive relationship between the commodity futures and its market as well as consumption betas. The average market and consumption betas are turnout to be 0.5 and 0.3 respectively. However, this positive relationship is statistically significant only in the case of combined exchanges commodity futures contracts and insignificant in the case of only MCX and only NCDEX commodity futures contracts.

Commodity wise analysis indicates that he following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation are such as Brent Crude Oil, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapas, Lead, Lead Mini, Nickel, Refined Soy Oil, Rubber, Silver, Silver Mini, Soyabean, Tin, Turmeric, Wheat, Zinc and Zinc Mini possess positively market beta coefficients. Similarly, the NCDEX's commodities such as Barley, Brent Crude Oil, Castor Seed, Chilli (Guntur), Copper, Light Sweet Crude Oil, Coriander(Kota), Raw Jute(Kolkata), Kapas, Nickel, Pepper (Kochi), R M Oil (Sri Ganga Nagar, Soymeal (Indore), Silver (Ahemadabad), Refined Soyoil (Indore), Wheat(Delhi) also possess positive market beta coefficients. These commodities on an average are very risky given their market beta levels. These commodities offers much higher returns whenever market returns are increasing and offers lower returns whenever the market is in the downside. These commodities are very well suited for the risk lovers.

Similarly, the following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation are such as Almond, Cardamom, Chana, Chana-Delhi, Flake Menthol, Gasoline, Guar Seed, Heating oil, Kapaskhali, Maize, Menthaoil, Pepper, Thermal Coal and Urad possess negative market beta coefficients. Similarly, NCDEX's commodities such as Castor disa, Chana, Cotton Seed Oilcake, Cotton Seed Oilcake Akola, Cotton Seed Oilcake Kadi, Copper since 2010, Furnace oil, Guar Gum , Gold Pure Mumbai Kg, Groundnut Expeller Oil, Groundnut(in shell), Gold, Gold 100 Grams , Gur, Gur MZFNR, Jeera, Jute Sacking, Yellow/Red Maize, Masoor Bold, Polypropylene, PVC, PVC - Mumbai, Rape Mustard Seed,

RM Seed, RMseed oilcake, Soyameal Export, Sesame Seed, Shankar Kapas(Rajkot), Silver5Kg Ahmd before 2008, Soya Bean, Turmeric, Yellow Peas, Zinc possess negative market beta coefficients. These commodities serve as insurance against a drop in the market returns. If someone adds these negative market beta commodities to their portfolio reduces the overall portfolio risk.

iii) The third objective is to assess the hedging effectiveness of the Indian commodity futures against inflation, and its components. The real purchasing power of the returns of their asset class is a matter of great importance for every investor, which means investors worry about the inflation threat. In the literature it has been proven that at least in the short to medium time horizon, most of the traditional asset classes are a poor hedge against inflation. The real purchasing power of returns will fall short of the expectations of investors if there is higher unexpected inflation, and investors will revise their expectations of future inflation accordingly to minimize their losses. Given the significance of the relationship between inflation and investments, it is very important to know whether the Indian commodity futures markets can act as an effective tool for hedging against inflation, whether expected or unexpected. Is there an exchange specific bias in hedging against inflation and its components? Does it matter whether the commodity futures contract still exists (continue to trade) or not and is there any sector specific bias in hedging against inflation and its components? Using regression models, we examine the effectiveness of commodity futures as an inflation hedge for investors over the period January 2004 to December 2014. The results indicates that commodity futures which trade on Multi Commodity Exchange (MCX) such as Aluminium, Aluminium Mini, ATF, Brent Crude Oil, CFI, Copper, Copper Mini, Crude oil, Heating oil, Maize, Refined Soy oil, Rubber, Silver Micro, Thermal Coal, Tin and Turmeric can be perfectly hedged against inflation and unexpected inflation. On the other hand, CER, Gold Petal, Gold Petal-Delhi and Lead can only be hedged against inflation. Among these hedgeable commodity futures, only Aluminium, Aluminium Mini, Brent Crude, Copper, Copper Mini, Crude oil, Gold Petal, Gold Petal-Delhi, Lead and Silver are still continuing to trade on MCX and the rest are not trading anymore.

Similarly, Commodity futures which trade on the National Commodity and Derivative Exchange (NCDEX), such as Aluminium, Brent Crude Oil, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper before 2010, Copper since 2010, Indian 31MM Cotton, Medium Staple Cotton,

Crude palm oil, Crude Oil, Cashew, Furnace oil, Gold, Kapas V797, Linear LD Polyethylene, Polypropylene, Black Pepper, PVC, RBD Palmolein, Rape Mustard Oil, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830), Steel Long, Soy oil-refined and Yellow Peas can be perfectly hedged against inflation and unexpected inflation. On the contrary, only Dhaniya (Coriander) and potato can be perfectly hedged against expected inflation. Only Brent Crude, Copper since 2010, Crude Oil, Gold, Kapas V797, RBD Palmolein, Mustard Seed, Shankar Kapas (Rajkot), Silver, Steel Long (BIS 2830) and Soy oil-refined still continue to trade on NCDEX and the rest are not trading anymore.

The following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation, are such as Copper, Crude oil, heating oil, Lead, Maize, Refined Soy oil, Rubber, Thermal Coal, Tin and Turmeric are positively related inflation. Similarly, the NCDEX's commodities such as Castor disa, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper since 2010, Furnace oil, Guar Gum, Gold, Masoor Bold, Polypropylene, PVC, Shankar Kapas (Rajkot) and Yellow Peas are also positively related inflation. These commodity futures can be perfectly hedged against inflation.

On the whole approximately forty five percent of the commodity futures (either on MCX or NCDEX or combined) can be perfectly hedged against inflation and unexpected inflation. Moreover, these perfectly hedgeable commodities against inflation and unexpected inflation do not belong to any specific sector; rather they are spread across agriculture, environmental, energy, precious and non-precious metals sectors. Among these perfectly hedgeable commodity futures most of them are not trading on either of the exchanges. However, majority of the perfectly hedgeable commodity futures belong to the agricultural sector. So, whenever there is rise in the inflation, these commodity prices rises and the value of commodity investments backing these goods also increases. Thereby the investor is saved from the inflationary effects. This overall analysis indicates that the Indian commodity futures can be better used to hedge against inflation and to its components such as expected and unexpected inflation.

iv) The fourth and final core objective is to assess the volatility in the Indian commodity futures markets. Since volatility is a major factor in pricing of commodity futures; any sudden changes in this component will have important ramifications not only for the pricing of commodity futures but also for the construction of optimal hedge ratios and this has a direct effect on

investor behavior. Given the importance of volatility in price discovery, we proceed with two symmetric GARCH namely, GARCH (1,1) and IGARCH (1,1) models, and two asymmetric GARCH namely, EGARCH (1,1) and TGARCH (1,1) models to account for positive and negative shocks on these commodity futures using the daily data of the Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) exchanges commodity futures contracts from January 2004 to December 2014.

Volatility analysis indicates that in most of the commodity futures of the MCX and NCDEX, the sum of ARCH and GARCH coefficients is one ($\alpha + \beta \approx 1$), which indicates that the underlying GARCH process is integrated. On an average on the MCX exchange, it takes 43 (estimated half-life value) days for a shock to volatility to diminish and on the other hand, it takes 44 days for a shock to volatility to diminish on NCDEX. All the commodity futures contracts (of MCX and NCDEX) conditional variance displays more autoregressive persistence (evident from the GARCH, mean lag and half-life value coefficients) because volatility reacts more intensively to market movements. Persistence of the shocks (evident from the GARCH, mean lag and half-life value coefficients) are not restricted to any specific sector of the commodity futures rather they are present in all the sectors. Commodity futures contracts such as Cardamom, Coriander, Cotton, Kapaskhali, Mentha oil, Thermal Coal and Turmeric of MCX and Raw Jute and Sugar M grade (Muzaffar Nagar) of the NCDEX possess larger ARCH (α) coefficients compared to GARCH (β) coefficients, which means that recent news influences these commodity futures price changes to a greater extent than older news and we can say that the shocks are more pronounced in the subsequent periods. All other commodity futures other than the above said, possess larger β (persistence) coefficients compared to (news) α coefficients, which means that the older news influences these commodity futures price changes rather than recent news, hence their conditional variance displays more autoregressive persistence. The estimated IGARCH model parameters for all the commodity futures of the MCX and NCDEX exhibit persistence in variance, which means that current information remains important for the forecasts of conditional variance for all horizons in all these commodity futures irrespective of the sector to which they belong. Thus, today's information is very crucial for forecasting into the future. Similarly, shocks are permanent to the system and these shocks to the conditional variance will never die out due to the persistence phenomenon.

The leverage effect (a negative shock to the return series is likely to increase volatility more than a positive shock of the same magnitude) is negatively significant in the case of Almond, ATF, Brent Crude, Cardamom, CER, Chana, Cotton, CPO, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Platinum, Refined Soy oil, Rubber, Tin, and Wheat of the MCX exchange and Cotton Seed Oilcake Kadi, Copper before and after 2010 contracts, Crude Oil, Groundnut Expeller Oil, Raw Jute, V 797 Kapas, Rape Mustard seed oilcake, Polypropylene, both the polyvinyl chloride contract (PVC), RBD Palmolein, Rape Mustard Oil, Soymeal (Indore), Shankar Kapas (Rajkot), Soya Bean, and Zinc of the NCDEX exchange. These commodity futures are markedly affected by bad news (negative shocks). The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this lead to a negative relationship between returns and volatility. There is an asymmetric (positive and negative shocks increase future volatility, but a negative shock has a larger effect than does a positive shock) effect in the case of agriculture, energy and environmental sectoral commodity futures and no asymmetric effect in the case of precious and non-precious sectoral commodity futures of the MCX exchange. Similarly, the asymmetric effect is present only in the case of agriculture, energy and non-precious sectoral commodity futures and no asymmetric effect is found only in the case of precious sectoral commodity futures. The absence of asymmetric effects makes the precious and non-precious commodity futures the better investment in anticipation of negative (bad) news for risk-averse investors on the MCX exchange and only precious commodity futures the better investment on the NCDEX exchange.

The following commodities from MCX, which offered higher returns than the bonds, Treasury bills and inflation, are such as Cardamom, Chana, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Refined Soyoil, Rubber and Tin's leverage effect is negative and significant. Similarly, the NCDEX's commodities such as Cotton Seed Oilcake Kadi, Copper since 2010, Groundnut Expeller Oil, Polypropylene, PVC, RM Seed, RM seed oilcake, Shankar Kapas (Rajkot), Soya Bean and Zinc's leverage effect is also negative and significant. The unexpected fall in the price of these commodity futures because of bad news increases predictable volatility more than a same size unexpected increase in price and this leads to a negative relationship between returns and volatility.

6.4: Concluding Remarks

The above observations at the aggregate index level clearly reveal that Indian commodity futures are offering higher nominal as well as real returns and risk premium compare to bonds, treasury bills and inflation. However, they are offering lower returns than the equity returns and risk premium. Commodity futures returns are positively correlated with the equity returns and inflation but negatively correlated with the bonds. The positive correlation between commodity futures returns and inflation makes the commodities as the best hedgeable asset class against inflation. On the other hand, the negative correlation between commodity futures returns and bonds makes the commodity futures as the better diversifiable asset class to reduce the overall portfolio risk. Commodity futures price fluctuations are lower compared to equity and some of the commodity future are riskier but they also offer higher potential returns and majority of these commodity futures serve as insurance against some risks that affect the overall portfolio adversely. The two types of equally weighted commodity futures analysis indicate that there is survivor and exclusion bias in the commodity futures. On an average, monthly holding period returns are much higher than the quarterly and yearly re-balanced (or holding period) returns. So, the frequency of re-balancing also matter a lot.

Similarly, at the commodity level also, they underperform the equity markets at the same time outperforming bond, treasury bills and inflation. The following commodities from MCX, which offered higher returns than the bonds, treasury bills and inflation are Brent Crude Oil, Copper, Crude oil, Gold, Gold Guinea, Gold Mini, Kapas, Lead, Lead Mini, Nickel, Refined Soy Oil, Rubber, Silver, Silver Mini, Soyabean, Tin, Turmeric, Wheat, Zinc and Zinc Mini and they possess positive market beta coefficients. Similarly, the NCDEX's commodities such as Barley, Brent Crude Oil, Castor Seed, Chilli (Guntur), Copper, Light Sweet Crude Oil, Coriander(Kota), Raw Jute(Kolkata), Kapas, Nickel, Pepper (Kochi), R M Oil (Sri Ganga Nagar, Soymeal (Indore), Silver (Ahemadabad), Refined Soyoil (Indore), Wheat(Delhi) also possess positive market beta coefficients. These commodities on an average are very risky given their market beta levels. These commodities offers much higher returns whenever market returns are increasing and offers lower returns whenever the market is in the downside. These commodities are very well suited for the risk takers lovers. Since the rest of high return yielding commodity futures are negatively related to market beta, they serve as an insurance against a drop in the market returns.

If someone adds these negative market beta commodities to their portfolio it reduces their overall portfolio risk.

Similarly, following commodities from MCX such as Copper, Crude oil, heating oil, Lead, Maize, Refined Soy oil, Rubber, Thermal Coal, Tin and Turmeric are positively related to inflation and the NCDEX's commodities such as Castor disa, Cotton Seed Oilcake, Cotton Seed Oilcake Kadi, Copper since 2010, Furnace oil, Guar Gum, Gold, Masoor Bold, Polypropylene, PVC, Shankar Kapas (Rajkot) and Yellow Peas are also positively related to inflation. Hence, these commodity futures can be perfectly hedged against inflation. On the other hand, the following MCX commodities', Cardamom, Chana, Crude oil, Flake Menthol, Gasoline, Heating oil, Maize, Pepper, Refined Soyoil, Rubber and Tin leverage effect is negative and significant. Similarly, the NCDEX commodities' Cotton Seed Oilcake Kadi, Copper since 2010, Groundnut Expeller Oil, Polypropylene, PVC, RM Seed, RM seed oilcake, Shankar Kapas (Rajkot), Soya Bean and Zinc leverage effect is also negative and significant. The volatility due to the unexpected fall in the price of these commodity futures due to bad news is more than the volatility due to a similar unexpected increase in price due to positive news and this leads to a negative relationship between returns and volatility.

Considering all the observations mentioned above, it may be said that the Indian commodity futures are an investible class of assets and are the next best alternative to the equity in India, given their relative position in terms of returns performance compared to all other investible class of assets in India. Further it is observed that majority of the commodity futures which offer higher returns and act as hedge against inflation, belong to agriculture and metals.

References:

Abanomey, W. S., & Mathur, I. (1999). "The hedging benefits of commodity futures in international portfolio diversification", *The Journal of Alternative Investments*, 2(3), 51-62.

Adrangi, B., Chatrath, A., & Raffiee, K. (2003). "Economic activity, inflation, and hedging: the case of gold and silver investments", *The Journal of Wealth Management*, 6(2), 60-77.

Aggarwal, N., Jain, S., & Thomas, S. (2014). "Do futures markets help in price discovery and risk management for commodities in India?", (No. 2014-020). *Indira Gandhi Institute of Development Research*, Mumbai, India.

Ajoy Kumar, M., & Shollapur, M. R. (2015). "Price Discovery and Volatility Spillover in the Agricultural Commodity Futures Market in India", *IUP Journal of Applied Finance*, 21(1).

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

Al-Rjoub, S. A. (2005). "The adjustments of stock prices to information about inflation: evidence from MENA countries", *Applied Economics Letters*, 12(14), 871-879.

Ankrim, E. M., & Hensel, C. R. (1993). "Commodities in Asset Allocation: A Real-Asset Alternative to Real Estate?", *Financial Analysts Journal*, 49(3), 20-29.

Arouri, M. E. H., Jawadi, F., & Nguyen, D. K. (2012). "Nonlinearities in carbon spot-futures price relationships during Phase II of the EU ETS", *Economic Modelling*, 29(3), 884-892.

Asprem, M. (1989). "Stock prices, asset portfolios and macroeconomic variables in ten European countries", *Journal of Banking & Finance*, 13(4), 589-612.

Babcock, B. A. (2012). "The impact of US biofuel policies on agricultural price levels and volatility", *China Agricultural Economic Review*, 4(4), 407-426.

Batten, J. A., Ciner, C., & Lucey, B. M. (2010). "The macroeconomic determinants of volatility in precious metals markets", *Resources Policy*, 35(2), 65-71.

Baxter, J., Conine, T. E., & Tamarkin, M. (1985). "On commodity market risk premiums: Additional evidence", *Journal of Futures Markets*, 5(1), 121-125.

Beckmann, J., & Czudaj, R. (2014). "Non-linearities in the relationship of agricultural futures prices", *European Review of Agricultural Economics*, 41(1), 1-23.

Behmiri, N. B., & Manera, M. (2015). "The role of outliers and oil price shocks on volatility of metal prices", *Resources Policy*, 46, 139-150.

Bekaert, G., & Wang, X. (2010). "Inflation risk and the inflation risk premium", *Economic Policy*, 25(64), 755-806.

Belousova, J., & Dorfleitner, G. (2012). "On the diversification benefits of commodities from the perspective of euro investors", *Journal of Banking & Finance*, 36(9), 2455-2472.

Bessembinder, H., & Seguin, P. J. (1993). "Price volatility, trading volume, and market depth: Evidence from futures markets", *Journal of financial and Quantitative Analysis*, 28(01), 21-39.

Bhar, R., & Hamori, S. (2008). "Information content of commodity futures prices for monetary policy", *Economic Modelling*, 25(2), 274-283.

Black, F. (1976). "The pricing of commodity contracts", *Journal of Financial Economics*, 3(1), 167-179.

Bodie, Z. (1976). "Common stocks as a hedge against inflation", *The Journal of Finance*, 31(2), 459-470.

Bodie, Z., & Rosansky, V. I. (1980). "Risk and return in commodity futures", *Financial Analysts Journal*, 36(3), 27-39.

Bollerslev, T. (1986). "Generalized autoregressive conditional heteroskedasticity", *Journal of Econometrics*, 31(3), 307-327.

Brorsen, B. W., & Irwin, S. H. (1987). "Futures funds and price volatility", *Review of Futures Markets*, 6(2), 118-135.

Busse, S., Brümmer, B., & Ihle, R. (2010). "Interdependencies between fossil fuel and renewable energy markets: the German biodiesel market", (No. 1010). *Diskussionspapiere//Department für Agrarökonomie und Rurale Entwicklung*.

Cao, B., Jayasuriya, S., & Shambora, W. (2010). "Holding a commodity futures index fund in a globally diversified portfolio: A placebo effect?", *Economics Bulletin*, 30(3), 1842-1851.

Caporale, T., & Jung, C. (1997). "Inflation and real stock prices", *Applied Financial Economics*, 7(3), 265-266.

Carbonez, K. A., Nguyen, V. T. T., & Sercu, P. (2010). "The asymmetric effects of scarcity and abundance on storable commodity price dynamics and hedge ratios", Available at *SSRN 1588073*.

Carter, C. A., Rausser, G. C., & Schmitz, A. (1983). "Efficient asset portfolios and the theory of normal backwardation", *The Journal of Political Economy*, 319-331.

Chang, E. C., Chen, C., & Chen, S. N. (1990). "Risk and return in copper, platinum, and silver futures", *Journal of Futures Markets*, 10(1), 29-39.

Chang, K., Wang, S. S., & Peng, K. (2013). "Mean reversion of stochastic convenience yields for CO 2 emissions allowances: Empirical evidence from the EU ETS", *The Spanish Review of Financial Economics*, 11(1), 39-45.

Chang, T. H., & Su, H. M. (2010). "The substitutive effect of biofuels on fossil fuels in the lower and higher crude oil price periods", *Energy*, 35(7), 2807-2813.

Chatrath, A., Adrangi, B., & Dhanda, K. K. (2002). "Are commodity prices chaotic?", *Agricultural Economics*, 27(2), 123-137.

Chatrath, A., Ramchander, S., & Song, F. (1997). "Stock prices, inflation and output: evidence from India", *Applied Financial Economics*, 7(4), 439-445.

Chen, M. H. (2003). "Risk and return: CAPM and CCAPM", *The Quarterly Review of Economics and Finance*, 43(2), 369-393.

Cheung, C. S., & Miu, P. (2010). "Diversification benefits of commodity futures", *Journal of International Financial Markets, Institutions and Money*, 20(5), 451-474.

Chkili, W., Hammoudeh, S., & Nguyen, D. K. (2014). "Volatility forecasting and risk management for commodity markets in the presence of asymmetry and long memory", *Energy Economics*, 41, 1-18.

Choi, K., & Hammoudeh, S. (2009). "Long memory in oil and refined products markets", *The Energy Journal*, 97-116.

Chua, J., & Woodward, R. S. (1982). "Gold as an inflation hedge: a comparative study of six major industrial countries", *Journal of Business Finance & Accounting*, 9(2), 191-197.

Cochran, S. J., Mansur, I., & Odusami, B. (2012). "Volatility persistence in metal returns: A FIGARCH approach", *Journal of Economics and Business*,64(4), 287-305.

Conover, C. M., Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2010). "Is now the time to add commodities to your portfolio?", *The Journal of Investing*, 19(3), 10-19.

Dasgupta, B. (2004). "Role of Commodity Futures Market in Spot Price Stabilization, Production and Inventory Decisions with Reference to India", *Indian Economic Review*, 315-325.

Daskalaki, C., & Skiadopoulos, G. (2011). "Should investors include commodities in their portfolios after all?", New evidence. *Journal of Banking & Finance*, 35(10), 2606-2626.

Deaton, A., & Laroque, G. (1992). "On the behaviour of commodity prices", *The Review of Economic Studies*, 59(1), 1-23.

Du, X., Cindy, L. Y., & Hayes, D. J. (2011). "Speculation and volatility spillover in the crude oil and agricultural commodity markets: A Bayesian analysis", *Energy Economics*, 33(3), 497-503.

Dummu, T. R. (2009). "Commodity Futures Markets in India: Its Impact on Production and Prices", *Indian Journal of Agricultural Economics*, 64(3), 333.

Dusak, K. (1973). "Futures trading and investor returns: An investigation of commodity market risk premiums", *The Journal of Political Economy*, 1387-1406.

Elam, E. W., & Vaught, D. (1988). "Risk and return in cattle and hog futures", *Journal of Futures Markets*, 8(1), 79-87.

Enders, W. (2004). "Applied Econometric Time Series", by *Walter. Technometrics*, 46(2).

Erb, C. B., & Harvey, C. R. (2006). "The strategic and tactical value of commodity futures", *Financial Analysts Journal*, 62(2), 69-97.

Fama, E. F. (1981). "Stock returns, real activity, inflation, and money", *The American Economic Review*, 545-565.

Fama, E. F., & French, K. R. (1987). "Commodity futures prices: Some evidence on forecast power, premiums, and the theory of storage", *Journal of Business*, 55-73.

Fama, E. F., & French, K. R. (1988). "Dividend yields and expected stock returns", *Journal of Financial Economics*, 22(1), 3-25.

Fama, E. F., & Gibbons, M. R. (1982). "Inflation, real returns and capital investment", *Journal of Monetary Economics*, 9(3), 297-323.

Fama, E. F., & Schwert, G. W. (1977). "Asset returns and inflation", *Journal of Financial Economics*, 5(2), 115-146.

Figuerola-Ferretti, I., & Gilbert, C. L. (2008). "Commonality in the LME aluminum and copper volatility processes through a FIGARCH lens", *Journal of Futures Markets*, 28(10), 935-962.

Foster, A. J. (1995). "Volume-volatility relationships for crude oil futures markets", *Journal of Futures Markets*, 15(8), 929-951.

Fung, H. G., & Patterson, G. A. (1999). "The dynamic relationship of volatility, volume, and market depth in currency futures markets", *Journal of International Financial Markets, Institutions and Money*, 9(1), 33-59.

Galvani, V., & Plourde, A. (2010). "Portfolio diversification in energy markets", *Energy Economics*, 32(2), 257-268.

Garcia, P., & Leuthold, R. M. (2004). "A selected review of agricultural commodity futures and options markets", *European Review of Agricultural Economics*, 31(3), 235-272.

Garcia, P., Leuthold, R. M., & Zapata, H. (1986). "Lead-lag relationships between trading volume and price variability: New evidence", *Journal of Futures Markets*, 6(1), 1-10.

Gardebroek, C., & Hernandez, M. A. (2013). "Do energy prices stimulate food price volatility? Examining volatility transmission between US oil, ethanol and corn markets", *Energy Economics*, 40, 119-129.

Geman, H., & Nguyen, V. N. (2005). "Soybean inventory and forward curve dynamics", *Management Science*, 51(7), 1076-1091.

Georgiev, G. (2001). "Benefits of commodity investment", *The Journal of Alternative Investments*, 4(1), 40-48.

Geske, R., & Roll, R. (1983). "The fiscal and monetary linkage between stock returns and inflation", *The Journal of Finance*, 38(1), 1-33.

Gil-Alana, L. A., & Tripathy, T. (2014). "Modelling volatility persistence and asymmetry: A Study on selected Indian non-ferrous metals markets", *Resources Policy*, 41, 31-39.

Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). "On the relation between the expected value and the volatility of the nominal excess return on stocks", *The Journal of Finance*, 48(5), 1779-1801.

Gorton, G., & Rouwenhorst, K. G. (2006). "Facts and fantasies about commodity futures", *Financial Analysts Journal*, 62(2), 47-68.

Gray, R. W., & Rutledge, D. J. (1971). "The economics of commodity futures markets: A survey", *Review of Marketing and Agricultural Economics*, 39(4), 57-108.

Greer, Robert J. "The nature of commodity index returns", *The Journal of Alternative Investments* 3.1 (2000): 45-52.

Hammoudeh, S. M., Yuan, Y., McAleer, M., & Thompson, M. A. (2010). "Precious metals–exchange rate volatility transmissions and hedging strategies", *International Review of Economics & Finance*, 19(4), 633-647.

Hardouvelis, G. A. (1987). "Macroeconomic information and stock prices", *Journal of Economics and Business*, 39(2), 131-140.

Hoevenaars, R. P., Molenaar, R. D., Schotman, P. C., & Steenkamp, T. B. (2008). "Strategic asset allocation with liabilities: Beyond stocks and bonds", *Journal of Economic Dynamics and Control*, 32(9), 2939-2970.

Huang, J. Z., & Zhong, Z. K. (2013). "Time variation in diversification benefits of commodity, REITs, and TIPS", *The Journal of Real Estate Finance and Economics*, 46(1), 152-192.

Inoue, T., & Hamori, S. (2014). "Market efficiency of commodity futures in India", *Applied Economics Letters*, 21(8), 522-527.

Jaffe, J. F., & Mandelker, G. (1979). "Inflation and the holding period returns on bonds", *Journal of Financial and Quantitative Analysis*, 14(05), 959-979.

Jagannathan, R. (1985). "An investigation of commodity futures prices using the consumption-based intertemporal capital asset pricing model", *Journal of Finance*, 175-191.

Jagannathan, R., & Wang, Y. (2005). "Consumption risk and the cost of equity capital", (No. w11026). *National Bureau of Economic Research*.

Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2000). "Efficient use of commodity futures in diversified portfolios", *Journal of Futures Markets*, 20(5), 489-506.

Jin, H. J., & Frechette, D. L. (2004). "Fractional integration in agricultural futures price volatilities", *American Journal of Agricultural Economics*, 86(2), 432-443.

Kamara, A. (1982). "Issues in futures markets: a survey", *Journal of Futures Markets*, 2(3), 261-294.

Kaufmann, R. K., & Ullman, B. (2009). "Oil prices, speculation, and fundamentals: Interpreting causal relations among spot and futures prices", *Energy Economics*, 31(4), 550-558.

Kenyon, D., Kling, K., Jordan, J., Seale, W., & McCabe, N. (1987). "Factors affecting agricultural futures price variance", *Journal of Futures Markets*, 7(1), 73-91.

Keynes, J. M. (1930). "A Treatise on Money": In 2 Volumes. *Macmillan & Company*.

Kogan, L., Livdan, D., & Yaron, A. (2009). "Oil futures prices in a production economy with investment constraints", *The Journal of Finance*, 64(3), 1345-1375.

Kroner, K. F., Kneafsey, K. P., & Claessens, S. (1995). "Forecasting volatility in commodity markets", *Journal of Forecasting*, 14(2), 77-95.

Kumar, S. (2004). "Price discovery and market efficiency: evidence from agricultural commodities futures markets", *South Asian Journal of Management*,11(2), 32.

Lien, D., & Yang, L. (2008). "Asymmetric effect of basis on dynamic futures hedging: Empirical evidence from commodity markets", *Journal of Banking & Finance*, 32(2), 187-198.

Lintner, J. (1965). "Security Prices, Risk, and Maximal Gains from Diversification", *The Journal of Finance*, 20(4), 587-615.

Lintner, J. (1975). "Inflation and security returns", *Journal of Finance*, 259-280.

Liu, D. Q., Williams, J., & Jorda, O. (2002). "Market-making behavior in futures markets", (Doctoral dissertation, Dissertation for Department of Agricultural and Resource Economics, Unpublished Dissertation, University of California-Davis).

Liu, Q., & An, Y. (2011). "Information transmission in informationally linked markets: Evidence from US and Chinese commodity futures markets", *Journal of International Money and Finance*, 30(5), 778-795.

Liu, Q., Wong, I., An, Y., & Zhang, J. (2014). "Asymmetric information and volatility forecasting in commodity futures markets", *Pacific-Basin Finance Journal*, 26, 79-97.

Lokare, S. M. (2007). "Commodity derivatives and price risk management: an empirical anecdote from India", *Reserve Bank of India Occasional Papers*,28(2), 27-77.

Majand, M., & Yung, K. (1991). "A GARCH examination of the relationship between volume and price variability in futures markets", *Journal of Futures Markets*, 11(5), 613-621.

Mankiw, N. G., & Shapiro, M. D. (1987). "Risk and return: Consumption versus market beta", (No. w1399). *National Bureau of Economic Research*.

Marcus, A. J. (1984). "Efficient asset portfolios and the theory of normal backwardation: A comment", *The Journal of Political Economy*, 162-164.

Marshall, B. R., Cahan, R. H., & Cahan, J. M. (2008). "Can commodity futures be profitably traded with quantitative market timing strategies?", *Journal of Banking & Finance*, 32(9), 1810-1819.

McQueen, G., & Roley, V. V. (1993). "Stock prices, news, and business conditions", *Review of financial studies*, 6(3), 683-707.

Morana, C. (2001). "A semiparametric approach to short-term oil price forecasting", *Energy Economics*, 23(3), 325-338.

Multi Commodity Exchange Ltd: http://www.mcxindia.com/

Naik, G., & Jain, S. K. (2002). "Indian agricultural commodity futures markets: a performance survey", *Economic and Political weekly*, 3161-3173.

National Commodity and Derivatives Exchange Ltd: http://www.ncdex.com/index.aspx

National Stock Exchange of India Ltd: http://www.nseindia.com/

Nazlioglu, S., Erdem, C., & Soytas, U. (2013). "Volatility spillover between oil and agricultural commodity markets", *Energy Economics*, 36, 658-665.

Nelson, C. R. (1976). "Inflation and rates of return on common stocks", *The journal of Finance*, 31(2), 471-483.

Nelson, D. B. (1990). "ARCH models as diffusion approximations", *Journal of Econometrics*, 45(1), 7-38.

Nelson, D. B. (1991). "Conditional Heteroskedasticity in asset returns: A new approach", *Econometrica: Journal of the Econometric Society*, 347-370.

Nissanke, M. (2012). "Commodity market linkages in the global financial crisis: Excess volatility and development impacts", *Journal of Development Studies*,48(6), 732-750.

Oberndorfer, U. (2009). "Energy prices, volatility, and the stock market: Evidence from the Eurozone", *Energy Policy*, 37(12), 5787-5795.

Parker, J. A., & Julliard, C. (2005). "Consumption risk and the cross section of expected returns", *Journal of Political Economy*, 113(1), 185-222.

Pearce, D. K., & Roley, V. V. (1985). "Stock prices and economic news", (No. w1296). *National Bureau of Economic Research.*

Pindyck, R.S., 2003. "Volatility in Natural Gas and Oil", MIT, Center for Energy and Environmental Policy Research, *Working Paper* 03-012

Poon, S. H., & Granger, C. W. (2003). "Forecasting volatility in financial markets: A review", *Journal of Economic Literature*, 41(2), 478-539.

Power, G. J., & Turvey, C. G. (2010). "Long-range dependence in the volatility of commodity futures prices: Wavelet-based evidence", *Physica A: Statistical Mechanics and its Applications*, 389(1), 79-90.

Roll, R. (1983). "On computing mean returns and the small firm premium", *Journal of Financial Economics*, 12(3), 371-386.

Routledge, B. R., Seppi, D. J., & Spatt, C. S. (2000). "Equilibrium forward curves for commodities", *Journal of Finance*, 1297-1338.

Sadorsky, P. (2002). "Time-varying risk premiums in petroleum futures prices", *Energy Economics*, 24(6), 539-556.

Sahadevan, K. G. (2002). "Sagging agricultural commodity exchanges: growth constraints and revival policy options", *Economic and Political Weekly*, 3153-3160.

Sahoo, P., & Kumar, R. (2011). “The impact of commodity transaction tax on futures trading in India: An ex-ante analysis”, *The Singapore Economic Review*,56(03), 423-440.

Satyanarayan, S., & Varangis, P. (1996). “Diversification benefits of commodity assets in global portfolios”, *The Journal of Investing*, 5(1), 69-78.

Schwert, G. W. (1981). “The adjustment of stock prices to information about inflation”, *Journal of Finance*, 15-29.

Schwert, G. W. (1989). Why does stock market volatility change over time?. *The Journal of Finance*, 44(5), 1115-1153.

Seifert, J., Uhrig-Homburg, M., & Wagner, M. (2008). “Dynamic behavior of CO 2 spot prices”, *Journal of Environmental Economics and Management*, 56(2), 180-194.

Sendhil, R., Kar, A., Mathur, V. C., & Jha, G. K. (2013). “Price Discovery, Transmission and Volatility: Evidence from Agricultural Commodity Futures”, *Agricultural Economics Research Review*, 26(1), 41-54.

Serra, T. (2011). “Volatility spillovers between food and energy markets: a semiparametric approach”, *Energy Economics*, 33(6), 1155-1164.

Sharpe, W. F. (1964). “Capital asset prices: A theory of market equilibrium under conditions of risk”, *The Journal of Finance*, 19(3), 425-442.

Skiadopoulos, G. (2013). “Advances in the commodity futures literature: a review”, *The Journal of Derivatives*, 20(3), 85-96.

So, J. C. (1987). “Commodity futures risk premium and unstable systematic risk”, *Journal of Futures Markets*, 7(3), 311-326.

Spierdijk, L., & Umar, Z. (2014). “Are commodity futures a good hedge against inflation?”, *Journal of Investment Strategies*, 3(2), 35-57.

Srivastava, S. P., & Saini, B. (2009). “Commodity Futures Markets and its Role in Indian Economy”, *Indian Journal of Agricultural Economics*, 64(3), 398.

Stoll, H. R., & Whaley, R. E. (2010). "Commodity index investing: speculation or diversification?", Available at *SSRN 1633908*.

Szymanowska, M., & de Roon, F. (2006). "Consumption risk and expected futures returns", *Discussion Papers*, 006.

Todorova, N., Worthington, A., & Souček, M. (2014). "Realized volatility spillovers in the non-ferrous metal futures market", *Resources Policy*, 39, 21-31.

Tomek, W. G., & Peterson, H. H. (2001). "Risk management in agricultural markets: a review", *Journal of Futures Markets,* 21(10), 953-985.

Tsay, R. S. (2005). "Analysis of financial time series (Vol. 543)", *John Wiley & Sons.*

Wahlroos, B., & Berglund, T. (1986). "Stock returns, inflationary expectations and real activity: New evidence", *Journal of Banking & Finance*, 10(3), 377-389.

Williams, J. C., & Wright, B. D. (2005). "Storage and commodity markets", *Cambridge University Press.*

Woodard, J. D., Fabozzi, F. J., Füss, R., & Kaiser, D. G. (2008). "Commodity futures investments: a review of strategic motivations and tactical opportunities", *The Handbook of Commodity Investing*, 56-86.

Worthington, A. C., & Pahlavani, M. (2007). "Gold investment as an inflationary hedge: Cointegration evidence with allowance for endogenous structural breaks", *Applied Financial Economics Letters,* 3(4), 259-262.

Yaganti, C. H., & Kamaiah, B. (2012). "Hedging Efficiency of Commodity Futures Markets in India", *IUP Journal of Financial Risk Management*, 9(2), 40.

Yang, J., Balyeat, R. B., & Leatham, D. J. (2005). "Futures trading activity and commodity cash price volatility", *Journal of Business Finance & Accounting*,32(1-2), 297-323.

Yang, J., Haigh, M. S., & Leatham, D. J. (2001). "Agricultural liberalization policy and commodity price volatility: a GARCH application", *Applied Economics Letters*, 8(9), 593-598.

Yang, S. R., & Brorsen, B. W. (1993). “Nonlinear dynamics of daily futures prices: conditional heteroskedasticity or chaos?”, *Journal of Futures Markets*,13(2), 175-191.

Zakoian, J. M. (1994). “Threshold heteroskedastic models”, *Journal of Economic Dynamics and Control*, 18(5), 931-955.

APPENDEIX

List of Articles published during the Research Period

1. (With Bandi Kamaiah) Risk and Return in Indian Commodity Futures Markets, Asian Journal of Research in Banking and Finance 5.6 (2015): 186-195.

2. (With Bandi Kamaiah) Are the Indian Commodity Futures a Good Hedge against, Asian Journal of Research in Business Economics and Management 5.6 (2015): 106.