# COMMODITY FUTURES AS AN ASSET CLASS:
# AN EMPIRICAL EVIDENCE FROM INDIAN MARKET

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## CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled **"COMMODITY FUTURES AS AN ASSET CLASS: AN EMPIRICAL EVIDENCE FROM INDIAN MARKET"** has been prepared by me under the joint guidance **of Dr. SHAILENDRA KUMAR,** Assistant Professor at Indian Institute of Information Technology, Allahabad and **Dr. PIYUSH VERMA**, Assistant Professor at LM Thapar School of Management, Thapar University, Patiala. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

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# TABLE OF CONTENTS

**Chapter No. Title** **Page No.**


| Chapter No. | Title | Page No. |
|---|---|---|
| | List of Tables | i |
| | List of Figures | iii |
| | Abbreviations | iv |
| 1. | Introduction | 1 |
| 2. | Literature Review | 10 |
| | 2.1 Research Gap | 26 |
| | 2.2 Problem Definition | 27 |
| 3. | Indian Commodity Futures Market | 29 |
| | 3.1 Structure and Functioning: Retrospective View | 29 |
| | 3.2 Performance and Growth: Retrospective View | 42 |
| | 3.3 Indian Commodity Futures: Investors' Perspective | 52 |
| 4. | Research Design | 56 |
| | 4.1 Objectives | 56 |
| | 4.2 Hypotheses | 57 |
| | 4.3 Data | 57 |
| | 4.4 Research Techniques | 61 |
| 5. | Analysis and Interpretation | 86 |
| 6. | Results of the study | 120 |
| 7. | Conclusions & Recommendations | 125 |
| | 7.1 Implications for the Banks | 127 |
| | 7.2 Implications for Investors/ Mutual Funds | 129 |
| | 7.3 Limitations | 130 |
| | 7.4 Future Scope of Study | 131 |
| | 7.5 List of Publications | 132 |
| 8. | Bibliography | 133 |
| 9. | Appendix A- Results of Monthly Data | 148 |
| | B- Glossary | 156 |

# LIST OF TABLES


| Table No. | Details | Page No. |
|---|---|---|
| 1 | Volume and Value of Trading in Indian Commodity Futures Market | 45 |
| 2 | Value in Rs. and Percentage of the Commodity Exchange to the Total Value Traded during 2013-14 | 45 |
| 3 | Correlation Matrix for the Returns on Asset classes (2005-2011) | 87 |
| 4.1 | Unit Root results for CF | 93 |
| 4.2 | Unit Root results for D(CF) | 94 |
| 4.3 | Unit Root results for Spot | 94 |
| 4.4 | Unit Root results for D(Spot) | 94 |
| 4.5 | Unit Root results for Equity | 95 |
| 4.6 | Unit Root results for D(Equity) | 95 |
| 4.7 | Unit Root results for Bond | 95 |
| 4.8 | Unit Root results for D(Bond) | 95 |
| 5 | Unit Root Tests results for all the Asset classes | 96 |
| 6.1 | Optimum Lag Length Selection CF and Spot | 97 |
| 6.2 | Optimum Lag Length Selection CF and Equity | 97 |
| 6.3 | Optimum Lag Length Selection CF and Bond | 98 |
| 6.4 | Results of Optimum Lag Length for all the Three Systems | 98 |
| 7.1 | Results of Johansen Cointegration between Commodity Futures & Spot | 99 |
| 7.2 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Spot | 100 |
| 8.1 | Results of Johansen Cointegration between Commodity Futures & Equity | 101 |
| 8.2 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Equity | 102 |
| 9.1 | Results of Johansen Cointegration between Commodity Futures & Bond | 102 |
| 9.2 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Bond | 103 |
| 10 | Vector Error Correction Estimates for CF-Spot | 104 |
| 11 | Vector Autoregression Estimates among CF and Equity | 107 |
| 12 | Vector Error Correction Estimates for CF-Bond | 109 |
| 13.1 | LM Test results among CF and Spot | 112 |
| 13.2 | LM Test results among CF and Equity | 112 |
| 13.3 | LM Test results among CF and Bond | 112 |
| 14.1 | Pairwise Granger Causality Test for CF and Spot | 113 |
| 14.2 | Pairwise Granger Causality Test for CF and Equity | 113 |
| 14.3 | Pairwise Granger Causality Test for CF and Bond | 113 |
| 15 | Sharpe Ratios (%) for the period 2005-2011 | 114 |
| 16 | Risk-Return Profile for construction of Efficient Frontier for Portfolio A (without commodity futures) | 115 |

| | | |
|---|---|---|
| 17 | Risk-Return Profile for construction of Efficient Frontier for Portfolio B (with commodity futures- composite index) | 116 |
| 18 | Risk-Return Profile for construction of Efficient Frontier for Portfolio C (with commodity futures- subindices ) | 116 |
| 19 | Maximizing the Utility with inclusion of MCX COMDEX (2005-2011) | 118 |
| 20 | t-test: Paired Two Sample for Means of CF and Spot | 120 |
| A1.1 | Unit Root results for M_CF | 149 |
| A1.2 | Unit Root results for D(M_CF) | 149 |
| A1.3 | Unit Root results for M_Spot | 149 |
| A1.4 | Unit Root results for D(M_Spot) | 150 |
| A1.5 | Unit Root results for M_Equity | 150 |
| A1.6 | Unit Root results for D(M_Equity) | 150 |
| A1.7 | Unit Root results for M_Bond | 150 |
| A1.8 | Unit Root results for D(M_Bond) | 151 |
| A2.1 | Results of Johansen Cointegration between Monthly Commodity Futures Prices & Monthly Spot Prices | 151 |
| A2.2 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF Prices & Monthly Spot Prices | 152 |
| A2.3 | Results of Johansen Cointegration between Monthly Commodity Futures Prices & Monthly Equity Prices | 152 |
| A2.4 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF Prices and Monthly Equity Prices | 153 |
| A2.5 | Results of Johansen Cointegration between Monthly Commodity Futures Prices & Monthly Bond Prices | 154 |
| A2.6 | Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF Prices and Monthly Bond Prices | 155 |

# LIST OF FIGURES


| Fig No. | Details | Page No. |
|---|---|---|
| 1 | Structure of Indian Commodity Market | 32 |
| 2 | Major Group of Commodities Traded during the Year 2013-14 | 46 |
| 3 | Line Graph for Commodity Futures Prices at its levels and first difference | 89 |
| 4 | Line Graph for Commodity Spot Prices at its levels and first difference | 90 |
| 5 | Line Graph for Equity Prices at its levels and first difference | 91 |
| 6 | Line Graph for Bond Prices at its levels and first difference | 92 |
| 7 | Efficient Frontier for the Portfolio A, B and C | 117 |

# ABBREVIATIONS

| | | |
|---|---|---|
| 1 | ADF/DF | Augmented Dickey Fuller/ Dickey Fuller |
| 2 | AIC | Akaike Information Criteria |
| 3 | AR(p) | Autoregressive model |
| 4 | ARCH | Autoregressive Conditional Heteroskedastic |
| 5 | CAL | Capital Allocation Line |
| 6 | CAPM | Capital Asset Pricing Model |
| 7 | CBOT | Chicago Board of Trade |
| 8 | CF | Commodity Futures |
| 9 | CISDM | Centre for International Securities and Derivatives Market |
| 10 | CRB | Commodity Research Bureau |
| 11 | D(variable) | Variable Differentiated to the first level |
| 12 | ECA | Essential Commodities Act |
| 13 | ECM | Error Correction Model |
| 14 | EME | Emerging Market Economies |
| 15 | FCRA | Forward Contract (Regulation) Act |
| 16 | FII | Foreign Institutional Investor |
| 17 | FMC | Forward Markets Commission |
| 18 | LM | Lagrange Multiplier |
| 19 | MCX | Multi Commodity Exchange of India Ltd. |
| 20 | MCX COMDEX | Commodity Futures |
| 21 | MCX SCOMDEX | Commodity Spot |
| 22 | MVO | Mean Variance Optimization |
| 23 | NCDEX | National Commodity and Derivative Exchange of India Ltd. |
| 24 | NMCE | National Multi Commodity Exchange of India Ltd. |
| 25 | NSE | National Stock Exchange |
| 26 | NSE G-Sec | NSE Government Securities |
| 27 | NSE TB | NSE T-bill Index |
| 28 | OLS | Ordinary Least Square |
| 29 | OTC | Over the Counter |
| 30 | RBI | Reserve Bank of India |
| 31 | S&P GSCI | Standard & Poor Goldman Sachs Commodity Index |
| 32 | SD | Standard Deviation |
| 33 | Spot | Commodity Spot |
| 34 | T-bill | Treasury Bills |
| 35 | UCX | Universal Commodity Exchange Ltd. |
| 36 | VAR | Vector Autoregressive model |
| 37 | VaR | Value at Risk |
| 38 | VECM | Vector of Error Correction Model |
| 39 | WPI | Wholesale Price Index |

# CHAPTER-1

## INTRODUCTION

Growing inter linkages among the global economies in the modern era, invites the flow of investment from the developed economies to emerging market economies (EMEs). Today the Indian economy is much integrated and interdependent than it was before the liberalisation and globalisation of the economy. The increasing global portfolio investments in India, led to generation of capital, employment and technological developments. The foreign inflows for the period April-January 2014-15 have grown US$ 25.52 billion, increase of 36 per cent year-on-year (y-o-y), from US$ 18.74 billion in the corresponding period (2013-14) last fiscal, according to Department of Industrial Policy and Promotion (DIPP) data. In 1970, the GDP of India was only $63.5 billion, which increased to $1.84 trillion in 2012, about 2900% increase in GDP. Despite the fact that the Indian economy is growing at the rate of 7.4% GDP and the increasing global funds in the market, the direct participation of retail investor is nearly 2% of the total population. This indicates that the domestic financial inclusion of the retail investor is low.

Increasing global fund investments helps the EMEs to grow but these economies have to bear the volatility spill-over of global markets. With the interdependencies of the economies, the financial crisis has become an important element of the modern financial system. Search for higher return and associated risk has become a common base for these crises. The crises that emanate from the developed economies not only affect their own markets but also have spill-over effect on the markets of emerging economies and other developing countries. During and even after these crises, stock markets witness huge stock price fall and volatility in the financial markets of the developed and developing economies. The fluctuations in the markets take a long time to recover back. The global financial crisis which started with the onset of US subprime crisis in August 2007 saw a fall of major banks and stock market worldwide. The Indian stock markets were badly affected by US financial crisis. There was a decline of 60 percent in the Indian indices and USD 1.3 trillion in market capitalisation was wiped since January 2008. This financial spill-over had evolved owing to the rising correlation between global equity prices and sudden reversal of capital flow leading to disastrous effect on the economy. From September to December 2008, there was a massive withdrawal of about USD 12 billion from Indian stock market by Foreign portfolio investors (Kumar, 2009), causing a psychological impact on national investors. The degree and intensity of this crisis had varied from country to country based on their financial system and markets. This crisis led to increase in the volatility pattern of stock price returns.

The volatility of returns had become a key issue for researchers, analyst and portfolio managers in financial markets. The stocks and other assets depend on the expected volatility of returns; therefore, banks and other financial institutions make volatility assessments as a part of monitoring their investment risk exposure (Kishor and Singh, 2014). In January-March 2012, FIIs invested USD 8.89 billion in the Indian stock markets, whereas during the same period, domestic institutions such as mutual funds, insurance companies etc., sold around USD 4 billion worth.

Equity market from emerging countries have different characteristics from the equity market of developed countries mainly in terms of high average returns, low correlations with developed market returns, more predictable returns, and higher volatility (Bekaert and Wu, 2000). These differences may have important implications in decision making by investors and policy makers. Thus, implementing the findings of developed markets on the emerging markets may mislead policy makers in making proper decisions (Goudarzi and Ramanarayanan, 2011). The need is to emphasise on increasing the financial inclusion of retail investors in India. While global benchmark derivative markets are trading at around 30 times their underlying physical markets, the Indian commodity futures markets is trading at less than 3 times the physical market despite the fact that it holds a formidable place in the world commodity economy (Economic Times, April, 2014).

Indian economy is still dependent of FIIs for capital flows as it is the major source of liquidity for not only India but many EMEs like China, Brazil and Russia. The combined stake of Indian Mutual Funds (2.68%) and Indian Financial Institutions/Insurance Companies (5.32%) is much less than the FIIs. Foreign Institutional Investors (FIIs) hold nearly 10.45% stake in listed Indian companies. They are the major investor segment in India, contributing to around 20% of turnover in equity and bond market. The volatility in these investments hampers the industrial and social development of the country. This dependency ought to be reduced by providing alternative and reliable source of investment for the retail investor. So this study explores the benefits of commodity futures as an investment tool.

The quest to stabilize and enhance returns in the post 2000 era, equity culture has led some individual and many institutional investors towards alternative investments. Usually an 'alternative asset' is defined as an asset class characterized by properties that are different from the traditional assets and which can be described as follows:

i. Low correlation with benchmark traditional assets, in particular with stock and bond markets.
ii. Capacity to generate high returns and possesses a high risk profile.
iii. The kind of investors: Usually high profile investors select alternative assets.
iv. The presence of discretionary elements in the selection of alternative asset class, requires a detailed knowledge of each particular alternative asset sector. In this context, it is very difficult to find a manager qualified in all these sectors (Liera, 2005).

The traditional choice of asset allocation for a risk averse investor in the portfolio includes stocks, bonds, treasury bills (T-bills) and real estate. Portfolio managers rely on volatility of an asset class to determine the portfolio performance. Volatility is the degree to which the price of an asset fluctuates. Volatility of stock returns in emerging markets has received considerable attention in recent years. The reason for this enormous interest is that volatility is used as a measure of risk. Due to uncertainty in the equity market returns and increase in interest rates seen in the recent past, the attention of portfolio managers and investors has shifted to alternative assets, like commodities, to earn extra returns. In view of the fact that the factors determining the commodity prices (such as weather, government policies, supply constraints and event risk) are different from the factors that determine the value of stocks and bonds. The key argument is that during the periods of unexpected inflation, the value of equity and bond tends to decrease, whereas commodity holdings rise in price with inflation. Thus, commodity acts as a natural hedge against unexpected price rise. Therefore, the diversifying properties that investors seek to balance their exposure to stocks and bonds can be obtained by investing in commodities (Bodie and Rosansky, 1980; Lee, Leuthold & Cordier, 1985; Anson, 1999; Edwards & Park, 1996). The benefits of diversification are best achieved when the investor holds a portfolio consisting of several asset classes that have the negative or low correlation between them.

An investor has an option to invest either in physical commodity, commodity futures, commodity linked stocks and mutual funds that invest in manufacturing companies of commodities. The investment in physical commodities is characterized by high carrying, storage costs, the perishable nature of commodities and the seasonal cycles for different commodities. Similarly investment in commodity related stocks, gives the investor an extra exposure to company specific risks like management competence of the company, trade risk and labour strikes (Laws & Thompson, 2007). On the contrary, it is relatively easy to purchase and sell commodity futures and therefore include them in the portfolio.

A commodity futures contract is an agreement to buy (or sell) a specified quantity of a commodity at a future date, at a price agreed upon, when entering into the contract. This agreed upon price at which the contract is made is called future price. In determining the futures price, market participants compare the current futures price to the spot price that is expected to prevail at the maturity of the futures contract.

The primary benefit of commodity futures market is that they provide **hedging against price risk** (Malhotra, 2012). Hedging is the method of offsetting the price risk in a spot market position by taking an equal and opposite position in the futures market. The producer can offset the losses in the spot market with the gains in the future market, by taking a short position in sport market and simultaneously, long position in futures market. Hedgers use the futures market to mitigate their price risk while speculators seek to profit from the price movements in the market and in doing so they provide much needed liquidity to the market.

Another important function of futures market is **price discovery**. Price signals are essential for the firms to take their production and marketing decisions. Price discovery is the process of determining the spot prices for a given commodity through the interactions between the buyers and sellers. It also implies how information is produced and transmitted across markets and whether these transmitted prices can be used as a reference price for the trading needs. Proper price discovery can help farmers and traders in avoiding price slumps in the post harvest period and also help consumers in coping with price volatility. If new information is reflected first in futures prices, the futures markets are said to perform the price discovery function efficiently.

Another function of futures market is to **support the small producers** by fulfilling their credit needs. If the inventory is hedged by investing in the futures market, the small buyers can earn better value for keeping the inventory as collateral (Malhotra, 2012).

Commodity futures can also act as **investment product** as they are different from financial assets. Equity raises resource for the firms to invest unlike commodity futures that provide insurance to the producers of agricultural and industrial products, for the future value of their outputs (or inputs). Commodity futures may not necessarily represent direct exposures to actual commodities. Investors in commodity futures receive compensation for bearing the risk of short-term commodity price fluctuations. By investing in commodity futures through standardised, organised and centralised exchanges, the risk is distributed among vast investors in return for a risk premium. Since the requirements and opinions of the market participants are different, it leads to the efficient price discovery in the spot market.

The above mentioned functions of commodity futures market, price discovery and price risk management can be best achieved in the presence of high liquidity which can be attained by allowing financial institutions like banks, mutual funds, etc to participate in commodity futures market. The Parliamentary Standing Committee examining the Forward Contracts Regulation Amendment Bill, 2010, noted in their report *"The Committee feel that the participation of Banks, Insurance Company and Mutual Funds, etc. would enable larger participation by professionals, which would improve the quality of price discovery, thereby leading to better price risk management". (Para 1.35 of the Standing Committee's Report).*

Although banks have huge exposure in agricultural and other commodities, yet they are not allowed to trade in commodity derivatives market for risk management. As on March 31, 2012, banks' total credit outstanding to the commodity sector was about `10.5 lakh crore, while the annualised volatility of commodities ranged between 9.5 to 64.3 per cent, indicating high risk exposure to commodities.

Allowing the financial institutions to hedge their risk by trading in commodity market, will facilitate the SME's and small farmers to participate in commodity futures. The manufacturing sector has to grapple with the broad-based volatility in commodity prices, maintaining profitability ad rigid end product price. Since the volatility in raw material prices makes it difficult for SMEs to carry cost effective business, that usually lack the bargaining power as compared to large corporates. SMEs can make more efficient decisions on production and diversification by using the risk management tools like futures as they can hedge their input and output prices, given an expected level of production.

Unlike its global counterparts, banks in India are not allowed to participate in commodity futures market, although it has exposure to the market risk since it provides lending to various participants of futures market. One of the East African Bank, Kenya Commercial Bank, hedged their lending operations to entities trading in commodity market, by backing their loans with forward contracts, and reduced their NPA provision by 57%.

CRDB Bank Ltd, a commercial bank based in Tanzania, was privatised and restructured in 1996. Before this, bank focused on agricultural lending and was a loss-making bank. The bank had significant role in cotton and coffee financing and agricultural commodities. But due to price volatility in the commodities market, it carried heavy risk and faced difficulties. After restructuring and privatisation, the bank implemented price risk management in two ways: firstly, by hedging its own overall portfolio related to coffee and cotton sectors by using risk management instruments and secondly, hedging its exposure by way acting as a market intermediary in carrying hedging transactions on behalf of borrowers.

According to Gorton and Rouwenhorst (2005), commodity futures have exhibited a negative correlation with stock futures and bonds & positive correlation with inflation, so they also tend to serve as an additional risk management tool. The results show that by holding the investment for 5 years, there is a statistically significant correlation of –0.42 among the returns of equity and commodity futures. Hence, they provide stability to the portfolio under volatile market conditions.

Jacobs et al (2014), have provided extensive evidence of individual investors making portfolio choices, that are difficult to reconcile with standard financial theory. The studies by Campbell (2006); and Kimball and Shumway (2010), have shown that participation by household investor in stock market is very rare. Puzzling investment behaviour is also observed when diversification over various asset classes in considered. Analyzing a large sample of retirement accounts, Agnew et al. (2003) showed that most asset allocations are either 100% or zero percent in equities and that the reallocation of assets is not done very frequently. Tang et al. (2010) concluded that most participants fail to create efficient portfolio investment choices for retirement plans. The failure of diversifying adequately over asset classes must be considered as particularly problematic as asset allocation is an important determinant of portfolio performance (Brinson et al. (1986); Ibbotson and Kaplan (2000)).

This study has tried to identify an alternative asset class to a traditional portfolio, by considering commodity futures, at the time of turbulence in the financial markets so as to enhance the Indian investor’s portfolio with high returns and lower risk. The diversification benefits of commodity futures are explored by analysing the short and long term relationship of commodity futures with other asset classes i.e., equity and bond using cointegration and granger causality. Further, the probing is done whether the selection of commodity futures to an alternative portfolio provide excess return or minimize risk as compared to a portfolio consisting of stocks and bonds using Mean variance optimization technique. Further, the concept of including alternative asset class is empirically tested by measuring a utility function and develop an understanding how risk aversion affects the asset allocation. The findings show that introducing commodity futures to a portfolio increases the returns without a corresponding rise in risk and with the increase in risk aversion levels of the investor, allocation to commodity futures tend to increase.

# CHAPTER-2

# LITERATURE REVIEW

This chapter presents the review of extant literature related to various aspects which are important and relevant in the context of present research. An asset class is a set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of that class (Greer, 1997). It is not sufficient that values of a group of assets simply have a low historical correlation with the values of another group of assets. If that would have been the case then the collection of stocks having low betas might be considered as a separate asset class from the stocks that make up the broader market indices. When determining the asset, one needs to differentiate between the assets themselves and the financial instruments derived from those assets.

There is recent increased interest in commodities as an asset class but the point to be considered is whether including commodities as an investment tool in the portfolio is a permanent strategic decision or temporary tactical decision. There are mixed evidences of diversifying properties of commodity futures, Denson (2006) suggest that commodities offer a zero expected risk premium and thus they are not desirable asset class. Whereas, Solnik and McLeavey (2004) recommend commodities as an asset class because they represent participation in the real economy and have a negative correlation with bonds and stocks. The literature consists of several studies on commodities. In particular, the authors have analyzed the contribution of commodities in terms of risk-return in a traditional portfolio composed of bonds and stocks.

The dearth of commodity futures studies in this area is puzzling, especially given that the literature shows that commodity futures possess positive skewness, high liquidity, low trading costs, low correlations with traditional assets, and abnormal returns, all of which potentially make them ideal securities to aid diversification (Chong & Miffre, 2010; Gorton & Rouwenhorst, 2006, Miffre & Rallis, 2007).

There are number of empirical studies that validate the negative correlation between commodity futures and equity over different time periods (Erb and Harvey, 2006, Gorton and Rouwenhorst, 2006, Büyüksahin et al., 2010, Chong and Miffre, 2010). These studies suggest that commodity futures provide diversification benefits by reducing the overall risk for a given level of return.

Bodie and Rosansky (1980), Fortenbery and Hauser (1990), and Conover et al. (2010) have examined whether incorporating commodities in the traditional asset portfolio of equity and bond, improves the risk-return profile of the investors. They found that by switching from an equity portfolio to a portfolio with both stocks and commodities, investors can reduce risk without sacrificing the return over the different periods 1950-1976, 1976-1985, and 1970-2007, respectively.

Bodie and Rosansky (1980) from their study calculated the returns for an equally-weighted cash collateralized portfolio of commodity futures over the time period 1949 to 1976. They have assumed a buy and hold strategy to avoid non-overlapping of holding periods and to examine to normal backwardation issue. They established that futures performed well during the periods when equity was underperforming and vice-versa. They substantiated that by holding 60% in equity and 40% in commodity futures, an investor can reduce the risk variability by one-third without compromising on the return and that commodity future also provide inflation hedge to the investors. They found that the portfolio had statistically significant excess returns that were similar in magnitude to those of the S&P 500.

Becker and Finnerty (2000) in their study reported that for the period, 1970 to 1990, the risk and return of the portfolio consisting of equity and bond improved significantly by including the commodities to the portfolio. They specified that during the periods of high inflation (in 1970's) the returns were much higher as compared to the periods of 80's or 90's. These results prove the hedging property of commodities against inflation.

Schneeweis and Spurgin (2000) explored the correlation among different asset classes that include stock index, bond index, crude oil futures, Real Estate Investment Trust (REITS), and commodity index. The results confirm that there is a significant negative correlation of commodity futures with equity, the exception of individual periods showing strong variation in leading indicators.

Erb and Harvey (2006) have assayed out that for the period 1969-2004, S&P GSCI has shown better return (12.2%) and lower standard deviation (18.35%) as compared to the return (11.2%) of S&P 500 index with standard deviation of 15.64%. By further analysing S&P GSCI, for the period 1982-2004, they created a portfolio of 12 commodities which were included in the S&P GSCI, and had been in the basket from the beginning of the index. The results show that their portfolio obtained an extra annual compound return of 4.49%, in comparison to 3.45% of Lehman Aggregate Bond Index and 7.35% of S&P 500 stock index. Especially, the energy sector had the best contribution to the final result with return of 7.06%, while silver showed an excess return of 8.09%.

Gorton and Rouwenhorst (2006) in their study have addressed the diversification benefits of commodity futures in their study. They pointed that taking a long position in commodities futures in long-term was comparable to stock long position and also offered high risk premium. For the period, 1959-2004, they analysed an equally weighted index of 34 commodities futures and identified that this index of 34 commodities had obtained returns equal to the returns earned on the benchmark stock at times of less risk. In details, the result demonstrates an excess return of 5.23%, i.e., close to the S&P 500 index and higher than the total return (2.22%) of Ibbotson Corporate Bonds. It is interesting to notice that the volatility (12.1%) is higher than that of the bond index (8.47%), but lower than that of the stock index (14.85%). This test shows the diversification effect of commodities with respect to a traditional portfolio, and its positive correlation with inflation. This correlation is higher (from 0.01 to 0.45), if the time interval increases from monthly to quinquennial. This test was first applied on American Commodity Futures Market, and then repeated on English and Japanese Markets and the results obtained were coherent with those of the American market.

From the above study it can be concluded that the average annualized return on the collateralized futures index was comparable to that of the S&P 500 index over the whole period of study and both the assets had outperformed corporate bonds. The researchers showed that the commodity futures returns are negatively correlated to other asset classes due to different behaviour of commodities over a business cycle. And that they are negatively related to inflation. Hence the paper concludes that the commodity futures are useful in constructing diversified portfolios with respect to the idiosyncratic component of returns.

Georgiev (2001), in his study has tried to explore the risk and return advantages offered by commodity investment, using Goldman Sachs Commodity Index (GSCI) for the period 1990-2001. The results indicate that GSCI has sources of risk and return that are distinct from the traditional portfolio of equity and bonds, therefore on its inclusion it offers the diversification benefits to the investors.

Jensen *et al.* (2002) investigated the S&P GSCI and some of its sub-indices for the diversification benefits of commodities as against the other asset classes over the period 1973 to 1999. The results substantiate that commodities have low correlation with other asset classes and the increase in performance of the portfolio is a result of inclusion of commodity futures. A further test made by CISDM in May 2006 analyzed the benefits of commodities in asset allocation portfolios composed of traditional portfolios at the beginning.

Kat and Oomen (2007) have examined the univariate return properties of a large variety of commodity futures, covering the period 1965 to 2005. They illustrated that volatility and kurtosis of commodity futures is comparable to that of US large cap stocks. Commodity futures returns vary considerably over different phases of the business cycle, under different monetary conditions as well as with the shape of the futures curve. The results suggested that some commodities can provide diversification to a portfolio of equity and bond than others.

Kat and Oomen (2006) have further explored the multivariate return characteristics of various commodity futures. The results display that commodity futures could provide a significant diversification on incorporating to a traditional investment portfolio. Adding commodity futures to a portfolio will not only reduce risk, but also expected return. Among the basket of commodities under study the only exception is energy, which does not appear to offer a risk premium. Making large allocations to energy in a commodity futures portfolio will substantially increase the risk as energy is more volatile than other commodities. And also, different types of energy commodity futures are strongly correlated.

Cheung and Miu (2010) addressed the diversification potential of commodity futures from the perspective of US and Canada investors and proved that commodity futures provide statistically significant diversification benefits in the long run. The low (high) return environment for commodity futures is associated with also low (high) volatility. This positive risk-return relationship is in contrast to the negative risk-return relationship for international equities. The paper finds that the long run diversification benefits are a result of infrequent outbursts in commodity markets. These benefits do not follow at the times when the commodity prices are in bearish trend. And also that, commodities as an alternative asset are more suitable for a conservative investor with high levels of risk aversion.

Chong and Miffre (2010) studied the conditional correlations between 25 commodity futures and 13 stock and fixed-income indices, using GARCH as volatility forecasting model to analyse the co-movement of commodity future returns with traditional asset classes. The data has been collected on weekly basis on Wednesday to avoid thing trading impact and maturity effect. Conditional correlations of 11 commodities with S&P 500 fell during the periods of high volatility in equity market. Thus implying that commodities should be treated a strategic asset in portfolio. The results also suggest that adding commodity futures to Treasury-Bill portfolios reduces risk further in volatile interest rate environments.

Basu and Miffre (2013) in their paper constructed factor mimicking portfolios to depict the effect of systematic hedging pressure on the risk premiums of commodity futures. To construct the portfolios they had bought the backwardated commodities and sold contangoed commodities. Their findings illustrate that these long-short portfolios outperformed the long only equity weighted portfolio by an average of 8.74% a year. They have suggested that our hedging pressure-based benchmarks be used as building block for strategic asset allocation or to appraise the performance of tactical asset allocation strategies in commodity futures markets.

Shroff and Karia (2007) studied the role of commodity futures in strategic asset allocation. They identified the case of commodity futures as an asset class by studying the performance of commodity future index under 4 different investment strategies, buy and hold strategy (near month roll over), buy and hold strategy (farther month roll over), buy and hold (2months – 1 month strategy), long short strategy based on contango and backwardation, and lastly, momentum based strategies. The authors concluded that a long-short strategy in commodity futures give significantly superior performance as compared to buy and hold strategy even during the period of downward trend in spot prices.

Ankrim and Hensel (1993) studied the diversification benefits of investing in commodities for the period 1972-1990. The article briefly describes the real assets and the rationale for investing in real estate and collateralised commodities. They concluded that by including the commodities to a traditional portfolio, the risk/return trade-off of optimal portfolios enhances for any given level of investor's risk tolerance coefficient. With addition of collateralised commodities to the portfolio, usually reduces the portfolio volatility more than increasing the returns, but comes at the expense of bonds.

Satyanarayan and Varangis (1996) examined the positive change in efficient frontier on incorporating commodity futures into portfolio of international assets for the period 1970-1992. The study by Abanomey and Mathur (1999) also followed the similar results for the 1970-1995. They found that the inclusion of commodities shifts the efficient frontier upwards, indicating improved risk-return profile for the investor.

Anson (1999) also addressed the asset property of commodity futures from a different perspective. The researcher constructed optimal portfolios by maximising the expected utility for investors at various risk aversion levels for the period 1974-1997. The results concluded that by adding commodity futures to a traditional portfolio of stocks and bonds, Sharpe ratio increases for the optimal portfolios. And, commodity futures are an excellent source of diversification over a longer time period. The researcher ascertained that with the increase in risk aversion levels, utility of commodity futures also increases.

Lee, Leuthold and Cordier (1985) studied the relationships between the stock market and the commodity futures market. The results showed that relative performances of the stock and commodity futures market appear to be sensitive to investment horizon. However risk and return increases with horizon, whereas skewness and kurtosis are generally negatively related to horizon. These results suggest that commodity futures contracts may be used in conjunction with an equity portfolio to help reduce risks and enhance portfolio returns.

Akey (2006) analysed whether an investor should combine commodities beta and alpha to achieve an attractive risk/return profile while maintaining the diversification benefits of commodities. The results validates that an active approach to include commodities may provide exposure that complements a long-only, passive investment and may help investors in producing a commodity allocation that is both a high risk-adjusted return source and a portfolio hedge.

Jensen et al. (2000) also found that for the period 1973-1997, including commodities to a traditional asset portfolio augments the risk return profile of the efficient portfolio.

Boido and Fasano (2009) examined the returns of the portfolio with commodities and portfolio without commodity (stocks, bonds and liquidity) for the period 1996-2006. They compared S&P GSCI returns with those of US CPI index and with the S&P GSCI Subindices. They extended this comparison to Italian Consumer Price Index and Italian Main Equity Market Index, S&P MIB. The results showed that incorporating the commodity to a portfolio brings an extra return to the investor as compared to a traditional financial portfolio.

Buyuksahin et al.(2010) empirically investigated the relationship between ordinary, as well as extreme, returns on passive investments in commodity and equity markets in order to verify whether the two move in a sync. The paper uses dynamic correlation and recursive cointegration technique and found no persistent increase in co-movements between the returns of commodity and equity over the study period. And also, identified that commodities provide substantial diversification benefits to passive equity investors, but not during the periods when it was required the most.

Belousova and Dorfleitner (2012) investigated the diversification contribution of several commodities to a portfolio of traditional assets for a Euro investor over the period

1995-2010. The results clearly indicate that the diversifying benefits differ across the commodities, where inclusion of precious metals and energy to the portfolio improves both the risk and return of the portfolio and other commodities like industrial metals, agricultural and livestock contribute in the reduction of risk.

Kaplan and Lummer (1998) exhibited in their study that during the period 1970 to 1996 the portfolio with commodity index earned higher returns with lower risk as compared to the traditional portfolio that has equity and bond.

Laws and Thompson (2007) analysed the asset like properties of commodities over the period from 1994-2007 by constructing a portfolio consisting of commodities, stock indices and money assets. The authors made the comparison of the portfolios with and without commodities and reached to the conclusion that adding commodities to a traditional portfolio increases the return with corresponding rise in risk.

Mishra (2008) has explored the advantages of adding commodity futures to a portfolio of equities in Indian context and concluded that there was less correlation of commodities with equity, and by adding it to the portfolio enhanced the risk adjusted return of the portfolio and improved the skewness and kurtosis of the returns.

Kumar and Pandey (2009) examined the hedging effectiveness for agricultural and non-agricultural future contracts traded in India using VECM and CCC-MGARCH Models. And found that agricultural commodities (30-70%) provide higher hedging effectiveness as compared to non- agricultural commodities (20%). They reported that hedging role of Indian commodities futures have increased with increase in trading activity.

Much of the previous research evidence indicates that diversification benefits are possible with an investment in commodity futures. Commodity futures represent an ideal addition to most equity portfolios due to low transaction cost, widely available investment vehicles, ease of trading and the negative correlation of commodities and inflation.

Thus, the above mentioned literature has provided unanimous evidence that investors are better off by including commodities in the portfolio but most of the studies that investigated the diversification benefits have done so for international markets.

Edwards and Park (1996) and Jensen et al. (2002), established in their tests that commodity futures produced lower returns in comparison to stock returns with higher volatility.

Daskalaki and Skiadopoulos (2011) investigated whether an investor is better off by including commodities to a traditional portfolio. They have applied utility analysis and regression techniques on two commodity indices and five commodity futures over the time period from 1989 to 2009. Their findings have challenged the diversifying properties of commodities across many datasets, utility functions and performance evaluation measures. The only exception to the results was the period from 2005-2008 when the prices of commodities was at boom.

Hochachka (2007) found that futures exhibit average excess returns and volatility similar to equities. However, the performance is largely confined to a 30-month period starting in mid-1972. Outside of this period the average return of commodity futures is not significantly positive and in the 1975-2006 period, it does not exceed the risk-free rate and indicated that the long-term strategic attractiveness of this asset class is very low.

The results show that an unnecessary hoarding will increase the carrying cost leading to a lower responsiveness of inventory to futures prices and finds out the effect of expected production shocks on futures price elasticity of supply.

Galvani and Plourde (2010) in their paper have evaluated the potential gain to a North American investor by diversifying his portfolio with energy commodity futures. The findings indicate that futures for crude oil, natural gas, and unleaded gasoline are effective in decreasing the overall level of risk borne by passive investors, but futures on energy commodities fail to increase the return to risk-bearing associated with efficient energy stock portfolios held by market participants who adopt a buy-and hold strategy.

Fama and French (1987) for the period 1967 to 1984, have investigated the performance of an equally weighted portfolio of up to 21 commodity futures and determined that there was only marginal evidence of statistically significant portfolio returns.

Jensen, Johnson and Mercer (2002) investigated the six commodity sub indices rather than limiting to a composite index and included the performance of both managed and unmanaged future strategies. The results provided evidence that commodity futures exposure is beneficial in tactical asset allocation strategies. Motivated by the expected linkage between commodity prices, inflationary developments, and the Federal Reserve's Monetary Policy stance, the authors find significant risk and return benefits from increasing commodity exposure during periods of Fed tightening, but virtually no benefit during periods of Fed easing.

Conover et al (2010) have re-examined the benefits of adding futures to a equity portfolio in different perspectives. They have examined equity portfolio along five different styles (value, growth, small cap, large cap and momentum), by considering alternative weights for commodity allocation (at 5%, 10% and 15%), contribution of commodity futures over a period of time and finally applying both the strategic and tactical approaches for futures allocation. Their results indicated that commodity futures offer considerable benefits to equity investors despite the equity strategy. The investors who follow conservative and aggressive investment strategies for including commodities, the investment benefits are significant. Furthermore, the benefits of adding commodity futures to an equity portfolio are enhanced significantly by using a tactical strategy that depends upon the Federal Reserve policy rates. When the Fed rates rises, a modest exposure to commodity futures will significantly increase the portfolio return and reduce the risk. On the contrary, when the Fed policy rates decreases, extending the portfolio with a modest exposure to commodity futures, results in a significant reduction in portfolio returns and simultaneous reduction in risk. Overall, on evaluation of the investment benefits of commodity futures indicates that, after controlling for changes in the Fed's policy rates, the benefits remain fairly consistent over time.

However, Silvennoinen and Thorp (2010), Tang and Xiong (2010), have pointed that the diversification benefits of commodities are uncertain due to the increasing presence of commodity index funds that integrates the investment market, i.e., commodity market with stock and bond markets.

The low correlation of commodity futures with other traditional asset classes appears to be driven by the unique performance of commodities during inflationary periods. One of the key elements of increased inflation and higher interest rates is the increasing commodity prices. However, both of them have negative impact on equities and bond. Therefore, long positions in commodity futures are found to provide an inflation hedge for equity portfolios. Gorton and Rouwenhorst suggest that the atypical exposure of commodity futures to unexpected inflation provides a potential explanation for their effectiveness in diversifying stock and bond portfolios.

See, for example Greer (1978), Bodie (1983), Irwin and Landa (1987), Edwards and Park (1996) and Greer (2007) in their studies discuss the view that, when included in a portfolio, commodity futures offer an inflation hedge.

Domanski and Heath (2007) through their research discussed the factors that are responsible for the increasing interest in commodities for investment and assess the extent to which the market characteristics changes with this increasing investments. They concluded that in terms of motivation and investors strategies, the commodity markets are similar to financial markets, but the physical characteristics such as inventory level, maintenance cost must be considered.

Lewis (2009) has outlined the role of commodities in maximising the long term wealth with the perspective of life-cycle investing. Life cycle investing is that at a younger age the investor is willing to take high risk and with the increasing age the risk appetite reduces. The researcher tried to identify whether an investor can gain by strategically investing in commodities during his working life. The results indicate that commodities do enhance the return and reduce the overall volatility, but at moderate allocation levels (10% to 40%). Allocation beyond this level would result in rapid erosion of excess return.

Stoll and Whaley (2009) evaluated whether speculative investing in commodity index is causing the increase in wheat futures and in general, commodity futures. The researcher summarised that commodity index investment is not speculative and the inflows and outflows in index don't cause fluctuation in commodity futures. The report has not undermined the effectiveness of future contracts as a risk hedging tool.

Scott (1994) argued that commodities require active management as they are overpriced from an investment point of view because of short-selling constraints and the price effects of consumer demand. But with the use of futures contracts, the problems of overpricing and short-sale constraints can be eliminated. A portfolio of futures and cash, by securitizing commodity price risk, becomes an acceptable proposition for passive management.

Schneeweis et al. (2000 and 2002) analyzed the benefits related to the choice of alternative investment in a traditional portfolio. This test was done by observing the changes of a Markowitz Efficient Frontier and by modifying the original asset allocation with alternative asset.

Simon (2013) modelled the conditional relationships between the Goldman Sachs's Total Return Commodity Index and Sub-Indices and the S&P 500 index using a bivariate GARCH framework. The results indicate that the diversification benefits of commodities have diminished over the sample period as the estimated conditional correlations remain low. Therefore, commodities do not provide meaningful diversification benefits to equity investors.

As Indian commodity futures market is at a nascent and turbulent stage, most researchers have concentrated on the role of futures trading in improving spot market efficiency (Karande (2006), Raizada and Sahi (2006)) and efficiency of futures in curbing the unexpected price movements (Ahuja (2006), Lokare (2007), Nath and Lingareddy (2008), Bose (2008).

Aggarwal et al. (2014) examined the price discovery and hedging effectiveness of commodity futures after the liberalisation of futures market and concluded that, on an average, futures prices do discover information relatively efficiently, but does not help to manage risk much efficiently. The paper uses the viewpoint of the hedger to also conjecture what factors may improve hedging effectiveness.

Malhotra (2012) and Kumari (2014) have tried to trace the origin, growth and trends of Indian commodity derivative market and identified the factors that are deteriorating the growth of futures market.

Soni (2012) investigated the linear and non-linear causality between commodity futures and spot returns for the period 2005-2011, and the results prove that futures play effective role in price discovery as there is strong flow of information from futures to spot market.

Reddy and Sebastin (2009) reported the dynamic linkages between commodity and stock market in India for the period from June, 2005 to September 2007 using Entropy

Theory. The researchers have demonstrated that interaction does exist between the two markets and transfer entropy is able to quantify the information transmission, identification of the direction of flow and in determining the memory level of the market.

Bose (2008) have looked upon the efficient functioning of the commodity futures market as this market is less developed as compared to equity market. It was identified that commodity futures market is similar to equity market in terms of efficiency and flow of information. Also that metal and energy futures can help in reducing the volatility of commodities spot market and in hedging the price risk because of the efficient flow of information but this does not hold true for agricultural futures.

Kamara (1982) compared the volatility in spot market before and after the introduction of futures trading to identify the impact of futures on spot prices. The results found that spot market volatility either reduced or at least did not increase with the introduction of commodity futures trading.

Lokare (2007) tested the efficacy and performance of commodity derivatives in steering the price risk management. The results divulge that these markets although are yet to achieve minimum critical liquidity and nearly all the commodities throw an evidence of co-integration in both spot and future prices. These evidences show that these markets are marching in the right direction of achieving improved operational efficiency, but at a slower pace. However, in the case of some commodities, the volatility in the futures has been substantially lower than the spot prices indicating an inefficient utilization of information. Hedging proves to be an effective proposition in respect of some commodities, while others entail moderate or considerably higher risk.

Dasgupta (2004) in his findings suggested that the allegation against futures market in India ‘that it distorts the spot market price and creates artificial scarcity by allowing unnecessary hoarding’, is a misconception. The author reported that there is a co-movement among futures price, production decision and the inventory decision. Future price elasticity of production is always greater than or equal to one, an increase in profit by increasing price is not possible, with the assumption that futures market is monopolistically competitive. Therefore, the doubt about its distorting effect on spot price should be ruled out.

Further, Singh (2000) investigated the hessian cash (spot) price variability before and after the introduction of futures trading (1988-1997). He used the multiplicative dummy variable model and concluded that futures trading reduced the price volatility in the hessian cash market.

Karande (2006) examined the important aspects of commodity futures markets in in terms of basis risk, price discovery and spot price volatility for Indian market. It was found that the futures market performed the function of price discovery and also had a beneficial impact on the spot price volatility.

Ahuja (2006) tried to investigate India's attempt to re-introduce the futures contract on several commodities. He pointed out that there is an urgent need to address certain factors for the successful functioning of the market which includes introduction of new market-based products, standardization of warehousing, nature of contract settlement, functions of regulator (s), integration of the markets, etc., which need urgent attention for the successful functioning of the market.

Raizada and Sahi (2006) studied that the efficiency and price discovery of wheat futures market and concluded that it shows weak-form inefficiency and fails to play the role of spot price discovery. They concluded that instead of futures price, it is the spot market that plays the leading role by capturing the market information much faster.

In essence, this research intends to find how the commodity futures and traditional financial assets move in the short and long term, and further utilise this knowledge for building the portfolios. The focus of the research is on general investment performance of alternative security classes, rather than the performance of various investment strategies. Thus, for each security class, the composite index is examined without considering the various possible sub-indices.

## 2.1 RESEARCH GAP

The risk reduction benefit of diversification is an important tenet of finance. However, diversification studies typically employ only stocks and bonds. Though there are many studies that have proved that adding commodities to a traditional portfolio for equity diversification (typically only using a commodity index or one category of futures to reduce risks) enhances the investor's benefits, but largely in the context of international markets. A meticulous study is conspicuously missing in the context of India. Most of the investors want to improve their risk/return profile, by enhancing the return and reducing the volatility. The modern portfolio theory suggests that diversification of portfolio is best achieved by including an uncorrelated asset to the portfolio. Therefore, as commodity futures prices are influenced by factors different from those that affect financial assets, commodity futures are perceived to be excellent candidate for the diversification of equity and bond portfolios (Mishra, 2008).

The empirical studies conducted on commodity futures in India have produced evidences, wherein the researchers have discussed the future market efficiency in predicting the spot prices, performance of commodity futures market, hedging properties of commodities and policy impact on commodity market, for different time periods. There are some studies of recent origin that have considered the diversifying property of commodities (Aggarwal et al 2008 and Mishra 2008), but in different framework as in number of assets considered for constructing the portfolio, time period of study, techniques used for identifying the diversification property of commodity futures.

Hence, this study tries to accomplish the literature gap by considering not only the short term co-movement of assets but also considering the long term movement among the suggested alternative asset and traditional assets. Since, the modern portfolio theory suggest that, constructing the portfolio with an asset that does not move in sync with the existing assets in long term, would enhance the portfolio return and reduce the overall risk.

## 2.2 PROBLEM DEFINITION

Above Review of Literature has shown that commodity futures when included into the traditional portfolio do improve the returns but most of the earlier studies that have been carried out in this context are confined to the global commodity markets only. In India, the studies available are few and they are in different frame of reference like efficiency of commodity future market, hedging advantages of futures from the farmers' perspective, etc.

This research is carried in two phases, the first phase examines the long term statistical relationship of commodity future prices with other asset classes and also investigates the short term dynamics of prices by testing for the existence and direction of inter-temporal Granger-causality between the indices. The second phase tests the diversifying properties of commodity futures by examining the role of commodity futures as an asset class in a traditional portfolio consisting of equity and bond using Mean variance optimization technique at various risk aversion levels of the investor. It also provides evidence that with the increase in risk aversion levels of the investor, allocation to commodity future tends to increase. An investor with long term investment horizon would benefit by including commodity futures to a traditional portfolio. The research has an aim of providing evidence by empirically analyzing the short & long run diversifying properties of commodity futures, on including it to a traditional portfolio of equity and bond.

The study intends to empirically answer the following questions related to the Indian commodity futures market:

1. How do spot and futures returns compare?
2. What are the returns on investing in commodity futures, and comparing these returns with the returns of stocks and bonds?
3. Are commodity futures riskier than traditional assets?
4. Does commodity futures provide hedge against inflation?
5. Can commodity futures provide diversification benefits on adding to a traditional portfolio of stocks and bonds?

## CHAPTER-3

# INDIAN COMMODITY FUTURES MARKET

### 3.1 STRUCTURE AND FUNCTIONING: RETROSPECTIVE VIEW

The beginning of commodity derivative market globally can be traced back to 1848, when Chicago Board of Trade (CBOT) was founded as a commodity exchange that emerged as an important channel for the producers and buyers of commodities to hedge their risk. The commodity futures market in India dates back to more than a century. With the establishment of Bombay Cotton Trade Association in 1875, that started trading in cotton derivative contracts and over time the derivative trading in oilseed and food grains also stated on BCT. Eventually, it led to the derivative trading in raw jute and jute goods at Calcutta in 1912, wheat derivative trading in Hapur in 1913 and bullions trading in Bombay. Before the World War II, the future contracts were being traded on certain agricultural commodities such as wheat, rice, sugar, groundnut, groundnut oil, raw jute, jute products and castor seed as well as precious metals. However, many feared that increased trading in futures will fuel the speculations in essential commodities that would be detrimental to the functioning of underlying commodity markets. Therefore, trading in many major commodities like oil seeds, food-grains, vegetable oils and cloth was banned. Also, during the Second World War, to maintain the supply of major commodities futures trading was further prohibited under the Defence of India Act.

It was later, after independence, specifically during the end of 1950s and beginning of 1960s, with the establishment of Forward Contracts (Regulation) Act, 1952, that the commodity futures trading picked up the momentum and there was an upswing in the commodity markets. However, in 1960’s, because of several years of severe drought, the farmers defaulted in their forward contracts, that gave a big blow to commodity futures trading and most of the commodities (essential or primary) were banned and futures trading continued only in two minor commodities, i.e. pepper and turmeric. Although in the 1970's and 1980s, the futures trading in some commodities like Potato, Castor seed, and Jaggery was permitted by the Government but it never regained the original volumes due to the doubts about the derivative trading as derivative markets were considered particularly as the terrain of unscrupulous speculation. Indian commodity derivative markets did not flourish much after that period.

But the revolution came with the liberalization and globalisation of the Indian economy in the early 1990s. In 1993, Government set up the Kabra Committee to examine the forwards market. The committee recommended in 1994 to allow trading in futures contracts that were banned in 1966 and add few more commodities. It suggested strengthening of FMC and some amendments to FCRA. The government accepted most of the recommendations and also allowed futures trading in 17 commodities as suggested by the committee. Six years later, the National Agricultural Policy 2000 recognised the positive role played by forward and futures market in price discovery and price risk management. The policy envisaged the removal of price controls in agricultural markets and introduced widespread use of futures contracts. However, the commodity futures market made the true restart in early 2000s with establishment of a number of recognised nationwide multi commodity exchanges.

In lieu of this, Government of India, permitted additional 54 commodities for futures trading. With the issue of this notification, prohibition on futures trading had been completely withdrawn. The mechanism of forward trading has actually developed and advanced considerably in the major trading nations of the world, like USA, UK, France, Japan, etc as compared to commodity futures market in India in terms of variety of products being traded like financial futures, shipping freights and interest rates etc.

Forward Contracts (Regulation) Act was enacted in 1952 to promote, regulate and develop the trading in forward and futures. The Forward Markets Commission (FMC) was instituted as a regulatory body in 1953 to oversee forward trading in commodities. The task of the commission was to monitor and regulate the trading of forward contracts since manipulation in these markets were expected to create severe imbalances with adverse welfare effects.

At present, future trading in India works at a three tire regulatory structure i.e. Government of India, Forward Market Commission and Commodity Exchanges. The Forward Markets Commission is the regulatory authority of the commodity futures market. Indian commodity futures market comprises six national exchanges, that regulate forward trading in 113 commodities and 11 commodity-specific regional exchanges recognized for regulating trading in various commodities approved by the Commission under the Forward Contracts (Regulation) Act, 1952.

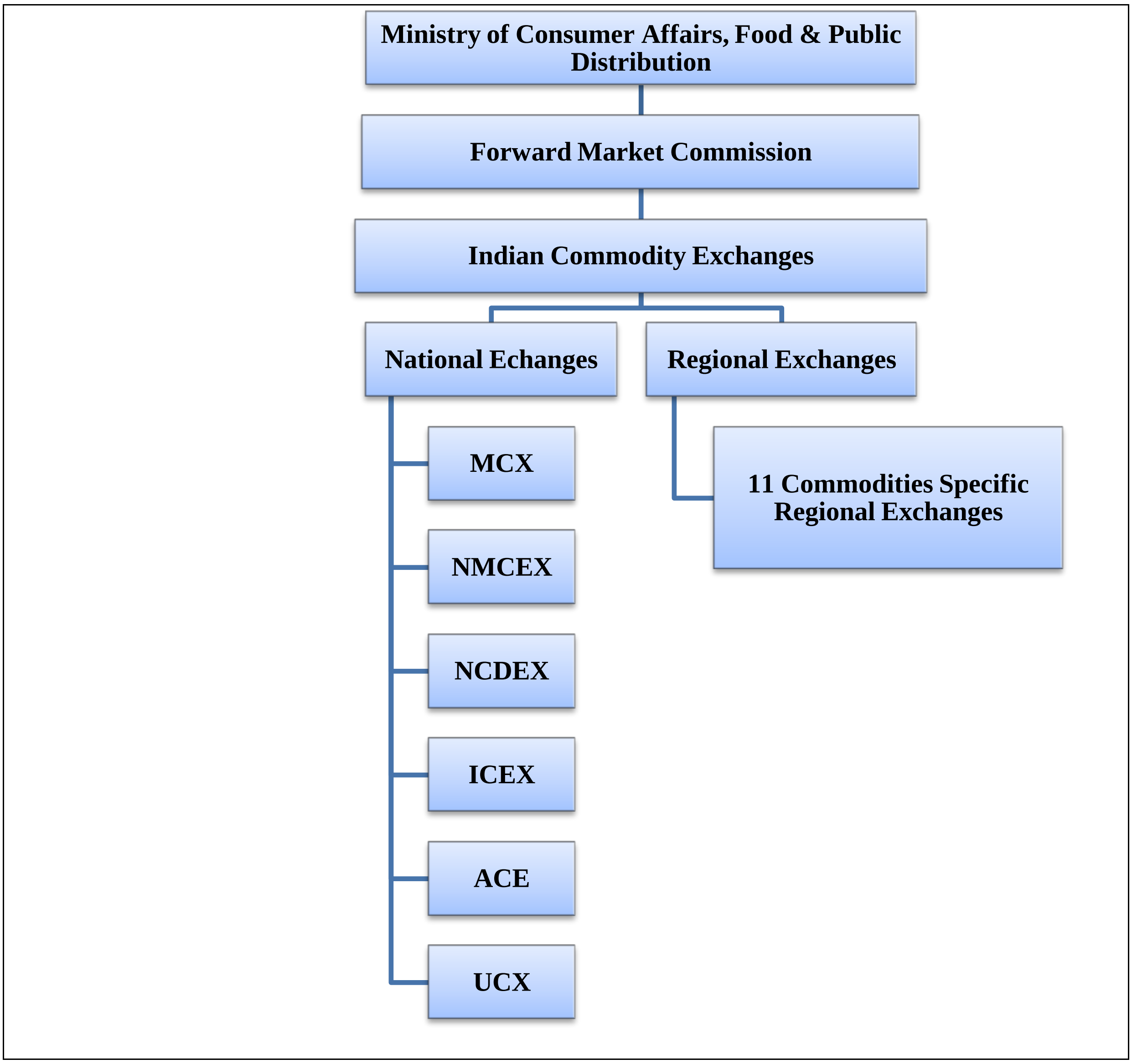
The national exchanges operating in the Indian commodity futures market are the Multi-Commodity Exchange of India Ltd. (MCX), National Commodity and Derivative Exchange of India Ltd. (NCDEX), National Multi Commodity Exchange of India Ltd. (NMCE), Indian Commodity Exchange Ltd. (ICE), ACE Derivatives and Commodity Exchange Ltd. and Universal Commodity Exchange Ltd. (UCX). India is one of the few countries worldwide which delivers commodities in electronic (dematerialised) form.

The different intermediaries and clients registered at various recognized National Exchanges (as on 31.3.2014) are,

| Members | Other intermediary | Warehouse service provider | Clients |
|---|---|---|---|
| 5098 | 251 | 42 | 40,15,781 |

Commodity exchanges deal with the actual implementation of rules related to conduct of trading and settlement of contracts and payments. The exchanges may impose circuit breakers to stop the trading for a specified period in futures contracts, if the market price moves out of a pre-specified range of values (band).

**Figure 1: Structure of Indian Commodity Market**




The commodities that are traded on these exchanges are:

i) Agricultural Products: Almonds, Basmati Rice, Castor Seed, Jeera, Mentha Oil, Rubber, Coffee, Guar Seed, etc.

ii) Energy Products: Crude Oil, Electricity, Thermal Coal, Natural Gas, PVC, etc.

iii) Environmental Products: Carbon (CFR) and Carbon (CFI).

iv) Ferrous Metal: Iron Ore and Steel.

v) Non-Precious Metals Products: Aluminium, Nickel, Steel, Lead, Copper, etc.

vi) Precious Metals Products: Gold, Platinum and Silver.

The central government has the legislative powers, subject to the approval of the Parliament, to pass, amend and repeal laws related to futures trading in India. In the aftermath of National Spot Exchange Ltd (NSEL) payment crisis in 2013, the Ministry of Finance has been appointed as the nodal ministry to deal with legislative matters.

Over the years, most of the regulatory powers of the central government have been delegated to FMC. It now functions under the administrative control of the Ministry of Finance. The FMC is expected to monitor, regulate and supervise the futures trading on commodity exchanges on a daily basis. It has the power to take regulatory measures such as imposing different types of margins, revision of open position limits, price limits and banning certain contracts wherever necessary. It also has a power to inspect the accounts of the exchanges and their members. All terms and conditions of a futures contract have to be approved by the FMC before it can be launched on commodity futures exchanges.

The Commission has kept the commodity futures markets well regulated. Due to the increasing speculation and market manipulation in the Indian commodity futures markets, FMC has imposed a series of new regulatory measures since June 2012:

i) Introduction of staggered delivery system.

ii) Imposition of special and/or additional margin deposits, to be collected on outstanding purchases or/and sales to curb excessive speculative activity through financial restraints. In September 2013, for instance, FMC imposed an additional special margin of 10 percent on futures contracts of guar seed and guar gum.

iii) Limit on price fluctuation (daily/weekly) to prevent unexpected movements in prices.

iv) Based on production data and market conditions, FMC has imposed reduction in open position limits to prevent speculative trading.

v) No contract in the lean season for agricultural commodities (for example, permission was not granted for February and March 2013 contracts in gram).

vi) Imposition of additional margin based on price volatility and market developments.

The commission has introduced staggered delivery system during the last 10 days of the expiry of the contracts in agricultural commodities, so as to ease the pressure of delivery of goods on the last day of the contract. To curb the excessive volatility in commodity prices, the commission does not allow the trading of futures contracts expiring in lean months, as the supply is short during this period.

At times, the commission takes extreme steps to curb shortages like skipping of trading in delivery of certain contracts, closing the markets for a specified period and even closing out the contract to overcome emergency situations. Moreover, to ensure that the prices reflected on the exchange platform are governed by the demand and supply factors in the physical markets, the regulator calls for the trading reports on the daily basis. Thus, to check excess speculation and price volatility, the futures market in commodities is kept under constant watch and surveillance. Other pro-active steps are taken by the regulator to ensure that the market is not misused.

Broadly, the commodities market exists in two distinct forms—the Over-The-Counter (OTC) market and the Exchange- Based market. Spot markets are essentially OTC markets and participation is restricted to people who are involved with that commodity, such as the farmer, processor, wholesaler, etc. A majority of the derivatives trading, on the other hand takes place through the exchange-based markets with standardised contracts, settlements, etc. The exchange-based markets are essentially derivative markets. These markets are similar to equity derivatives in their working as things are standardised and a person can purchase a contract by paying only a percentage of the contract value. A person can also go short on these exchanges. Moreover, even though there is a provision for delivery, majority of the contracts are squared-off before expiry and are settled in cash. As a result, there is an active participation by even those people who are not associated with the commodity.

There exists a transparent and fair price discovery in commodity futures market on account of large-scale participation of different entities, reflecting diverse views and expectations of a wide section of investors related to commodity market. It provides an effective platform for price-risk management for distinct players in the market ranging from producers, traders, processors, exporters/importers and even to the end-users of a commodity.

The exchanges comprehensively define the delivery and settlement procedure that vary for each commodity in terms of place of delivery, options, quality implications, penalties and margins. Members of an exchange can trade and clear transactions in only those contracts that are specified by the exchange and approved by the FMC.

**Margin Requirements**

Buyers and sellers are required to maintain a certain amount as initial margin, including a special margin (as applicable) on their respective future positions in the excahnge. These margins vary for each commodity and for different contract months depending upon factors such as market volatility, government policies, macro-economic factors, international price movements, etc.

The exchange specifies the methodology to determine the margin provisions, subject to margin requirements which are settled by the clearing house of the exchange. For example, the exchange can levy an initial margin on derivatives contracts using the concept of Value at Risk (VaR) or any other concept as prescribed. Additional margins are levied for deliverable positions on the basis of VaR from the expiry of the contract till the actual settlement date, including a mark-up in case of default. The estimated margin (based on the prescribed methodology) may be in any way as determined by the exchange such as on net position basis, gross position basis, client level basis, etc.

Every clearing member is also required to maintain an appropriate margin account with the clearing house of the exchange. This is done against the aggregate open positions cleared by the clearing member in respect of (i) the clearing member's own account, (ii) for other members of the exchange with whom the clearing member has an agreement and, (iii) clients, where applicable.

Margin accounts of all exchange members are marked on daily basis and the exchange members are required to pay the amount stipulated by the clearing house. The entire day's trades and open positions on the exchange are marked to closing price for the respective futures contract, on the basis of which the hypothetical gain or loss is estimated. The investors are required to collect or make compensation for this amount at the end of each trading day. The exchange also prescribes additional or special margins as may be considered necessary during the delivery period and emergencies. Every member of the exchange executing transactions on behalf of clients is expected to regularly (time interval is exchange specified) collect the margins from their clients against their open positions.

During the working day, relevant authorities have the right to affect marking to market and settlements, more than once through the clearing house, if considered fit on account of market risks and other parameters. Settlement of differences that are due on outstanding transactions shall be made by the clearing members through the clearing house. This provision prevents the possibility of a potential loss where any of the contracts' participants might default on their contractual obligations. The exchange has a power to impose any disciplinary action on any member or a client when they fail to pay the variation margin that is required to maintain the minimum margin requirements. This may even include suspension of the exchange members.

**Clearing and Settlement**

All futures contracts are settled through the clearing house of each exchange. The settlement, clearing and guaranteeing services of the clearing house can be exercised exclusively by the clearing members. The clearing house also registers on the exchange, the financial performance of the contracts entered into. Each exchange has a pre defined eligibility criterion for a person to be qualified as a clearing member.

To facilitate smooth clearing and settlement of future contracts, all exchange members who participate in futures trading are required to have bank accounts with designated clearing banks as may be advised by the exchange. All members are required to strictly follow the instructions issued by the exchange with respect to the operation of such bank accounts. Specifically minimum balance, segregation of clients' fund and own fund, etc. The members should also submit an irrevocable mandate in writing so as to enable the exchange to debit and credit their settlement account electronically. They are therefore required to maintain sufficient funds in their accounts, to enable the exchange to recover its dues by debiting it.

Each clearing member has to submit all the trades executed by clients or constituent members with whom the firm has such an agreement to assist the clearing house in a pre-arranged form and manner to effectively manage the clearing facility.

The clearing house processes all transactions submitted and accepts only the net liability of the clearing member. Once a contract is matched, it is marked to market by the clearing house. And, the exchange becomes the counter party for all net financial liabilities of the clearing members and specifically, for all the commodities or contracts in which the exchange has decided to accept the responsibility as guarantor for the financial obligations.

**Delivery**

The provision for delivery is included in futures trading to make sure that the futures prices in commodities are in sync with the actual price of underlying commodities traded in the spot markets. However, in reality, deliveries account for less than 0.1 percent of the total trading in futures contracts in India. Almost all contracts are traded not with the intention to take/give delivery but for purely speculative purposes and are settled in cash as per the Final Settlement Price (FSP). Even in instances where exchanges have introduced compulsory delivery in price-sensitive agricultural commodity contracts (such as pepper, turmeric and gram), the low penalty rates (ranging from 1.5 percent to 3 percent in case of delivery default) fail to act as a deterrent to speculators.

In addition to speculative trading, there are other important factors responsible for low delivery volumes. These include limited accredited warehouses in the country, poor credibility of warehouse receipts, delivery centres located at distant locations which incur substantial transportation costs, different grades of underlying commodity, and countless regulations imposed by state governments on the inventory and movement of the underlying commodity.

The early delivery system has been recently introduced in the Indian commodity futures markets for making futures trading more delivery oriented and to reduce excessive speculation and price volatility, especially towards the contract maturity date. In staggered delivery system, the markets participants have the facility to liquidate their positions before the expiry of the contract, by informing their delivery intention 15 days before the close of the near-month contract. It has also been observed that the staggered delivery system has reduced excessive speculation and price volatility in the near-month contracts, as speculators have moved to far month contracts with no pressure of delivery of goods.

The exchange may prescribe tender days and delivery period for each contract month during which a seller who wishes to opt for tender delivery may issue delivery orders through specific clearing members. Tender days and delivery period end on or before the last day of trading of the relevant contract month.

As specified in the contract, on the last trading day of the contract month of the maturing contract, all outstanding contracts will be closed-out at the due date rate. The relevant authority penalises the sellers with outstanding positions who fail to issue delivery orders. The exchange may financially compensate the buyers who hold outstanding positions and intend to take delivery but could not receive delivery orders against such positions due to the default of the seller.

**In Case of Cash Settlement**

The buyer who fails to accept delivery orders is expected to pay the difference between the settlement price and the due date rate. In addition, the buyer will also have to pay a penalty, as ascertained by the exchange. The member defaulting in paying the dues and penalties related to closing out within the stipulated period causes him to be declared a defaulter, and renders him liable for disciplinary action. The seller, who tenders the delivery document, is compensated with the penalty recovered from the buyer and the delivery is returned to the seller.

**In Case of Physical Delivery**

An exchange member when desires to tender goods against an open short position in the maturing contract sends the delivery orders to the clearing house through the clearing member up to such time on the stated tender days. The delivery order forms are duly signed by the sellers or seller's representative, holding short open positions, should offer the following information, in addition to the particulars in the delivery order:

i) Specification of Goods to be delivered in terms of quality, quantity, delivery order rate (to be mentioned by the clearing house), period of delivery, and
ii) Specifications of the Seller issuing the delivery orders in terms of name of the seller, address of the warehouse(s) or any storage place where the goods are kept mentioning the quantity of commodity at each warehouse, and the name and address of the seller's representative who should be contacted by the buyer for collecting the delivery

A seller is entitled to offer delivery only at the exchange determined by the delivery centres. The delivery can only be tendered at the specified centres, strictly as per the contractual delivery procedure. Before tendering delivery, the seller is required to obtain a certificate from a surveyor appointed by the exchange. The seller tenders the certificate along with the delivery order to the clearing house. The surveyor's certificate clearly stipulates the quality of the goods tendered and also confirms whether such quality of good is tenderable as per the contract specification of the exchange. In case of non-compliance with any of the conditions, the delivery order is rejected and clearing members shall, in turn, assign the full quantity of goods covered by the delivery orders to their clients holding outstanding long positions.

**Commodity Transaction Tax**

Commodity transaction tax (CTT) is a tax levied in India on transactions done on the domestic commodity futures exchanges. It is similar to a Financial Transaction Tax (FTT), which is commonly associated with transactions done in the financial sector.

On February 28, 2013, India introduced a transaction tax on the commodity futures trading under the direct tax provisions in the Union Budget 2013-14. CTT is levied at 0.01 percent (Rs.10 for transaction worth Rs.1 lakh). CTT is levied only on non-agricultural commodities futures contracts (e.g., gold, copper and oil) traded in the India. On the other hand agricultural futures contracts are exempted from CTT. The tax is payable by the seller of futures contract. The finance ministry’s rationale for introducing CTT was to bring commodity markets on par with the securities market where a securities transaction tax is being levied since 2004.

India is the second country in the world to introduce a tax on commodity futures trading. In 1993, Taiwan imposed a transaction tax of 0.05 percent on the value of the commodity futures contract (Mahajan and Singh, 2015).

**Additional practices**

To facilitate transparency, a cost-effective trading system and to avoid information asymmetry, other functions of the exchanges, in regard to trading are determination of the transaction and clearing fees that is payable by the members of the exchange for trading in different commodities and all other charges that are be collected by the exchange from members, registered non-members, participants, approved users, etc. Moreover, the exchange is responsible for fixing the units of trading, the minimum and maximum quantity of contracts traded to be purchased or sold. The exchange also monitors the limits on price fluctuations permitted in a day or for a particular time period for a particular commodity. This is implemented to avoid acute price volatilities among the commodities.

The exchange also keeps the intention of carrying out periodic and specific checks and inspections related to procedures involved in trading, price manipulation, price distortion and other trading malpractices. For monitoring the same, major national exchanges have a vigilance committee in place. Commodity-specific experts constitute the senior executives in an exchange to identify such malpractices and maintain an investor-consumer responsive trading environment.

Further, investor awareness in terms of the commodities trade jargon and risk implications is some of the information which is widely disseminated by the way of online and other media publications, press releases, exchanges' websites, etc. However, the procedure for the same may differ for each exchange. Moreover, the risk disclosure document provides basic and important insight into the risks associated with trading in commodity futures.

## 3.2 PERFORMANCE AND GROWTH : RETROSPECTIVE VIEW

Commodity derivative trading is currently governed by the Forward Contract Regulation Act (FCRA). This law prohibits options trading and OTC commodity derivatives. Presently, in India, only exchange-traded commodity futures are allowed. However, government has made certain amendments in FCRA, which allowed the introduction of new products such as weather derivatives.

The FMC has initiated several measures to stimulate active trading interest in commodities. Steps such as lifting the ban on futures trading in commodities, approving new exchanges which offer modern infrastructure and systems are seen to be path breaking. Other than these removing legal hurdles to attract more participants have increased the scope of commodity derivatives trading in India. This has lead to boost in both the spot market as well as the futures market in the country. The trading volumes are increasing while the list of commodities traded on the national commodity exchanges also continues to expand.

Out of 17 recognized exchanges, 6 national commodity exchanges MCX, NCDEX, NMCE, ACE, UCX and ICEX, contribute 99% of the total value of the commodities traded during the year 2013-14 (FMC Bulletin, 2104). Out of the 113 commodities, regulated by the FMC, in terms of value of trade, Bullion, Energy, Agricultural commodities and Metals are the prominently traded commodities. Among agricultural commodities, the major share in terms of value of trade attributes to Castor Seed, Refined Soya Oil, Soya bean, Chana and Coriander. The total volume of trade across all Exchanges in 2013-14 was 8,832.76 lakh MT at a value of Rs. 101 lakh Crores. The total of deliveries of all commodities on Commodity Exchange platform is 9,23,893 MT during the year 2013-14.

In terms of total number of contracts traded, MCX has become the world's largest commodity futures exchange in gold and silver, second largest in natural gas, and third in crude oil. The top four commodities (gold, silver, copper and crude oil) form 85 percent of MCX's total trading business. NCDEX, on the other hand, deals with a large number of agricultural and metal commodities, while NMCE's portfolio includes major agricultural commodities and metals.

The total size of commodity futures market was Rs.170, 468 billion (around $2,705 billion) outstanding in the financial year 2012-13 (Table 1), registering a compounded annual growth rate (CAGR) of nearly 40 percent since 2003. In contrast, India's Gross Domestic Product (GDP) was worth $1,841 billion in 2012. The monthly turnover in Indian commodity exchanges is next only to the US and China. During 2011-12, the total volume of trade across all commodity exchanges in India was 140,257 million metric tonne (MT), out of which deliveries were merely 888,250 MT (0.0000006 percent). This data clearly shows that actual delivery of commodities is extremely low in the Indian futures markets. (Mahajan and Singh, 2015).

Over the years, the composition of trading in the Indian futures markets has dramatically changed. For instance, agricultural commodities constituted 69 percent of total value of trade in 2004-05 and the rest was in bullion and metals. In 2012-13, the share of bullion and metals rose to 65 percent and agricultural commodities declined to 12 percent. The international markets and foreign exchange rate influence the movement of futures prices of bullion and metals to a larger extent.

The turnover of the commodity market in our country has grown potentially in a short span of time. It largely favours the speculators because of skewed market. The future market leaves a lot to be desired as an effective instrument of risk management and price discovery for the benefit of the growers, traders, processors and other stakeholders. The opening up of the commodity future market in India was an important initiative taken with an aim to improve domestic market efficiency. It further aids the price discovery process leading to a platform for price risk management in commodities. In September 2013, the regulatory body FMC has been brought under the control of Ministry of Finance.

**Table 1: Volume and Value of Trading in Commodity Futures Market**

| Year | Volume of Trading (In lakh tonne) | Value of Trading (In Rs. Crores) |
|---|---|---|
| 2013-14 | 8832.76 | 10144794.98 |
| 2012-13 | 14510.08 | 17046840.09 |
| 2011-12 | 14025.74 | 18126103.78 |
| 2010-11 | 12805.57 | 11948942.35 |
| 2009-10 | 10142.93 | 7764754.05 |

Source: Forward Markets Commission, Annual Reports.

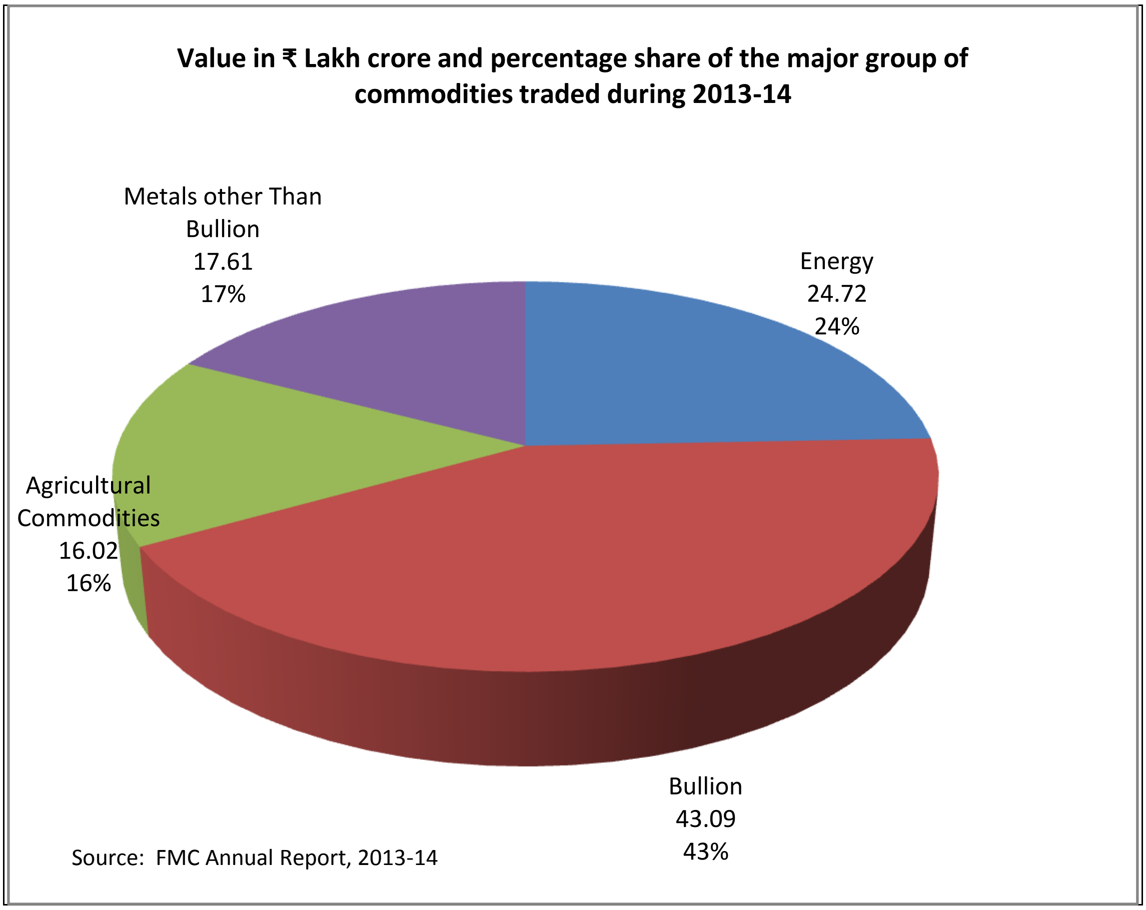
**Table 2: Value in Rs. and Percentage of the Commodity Exchange to the Total Value Traded during 2013-14.**

| Exchange | Value(Rs) | Percentage |
|---|---|---|
| NCDEX, Mumbai | 1146328.09 | 11.33% |
| NMCE, Ahmedabad | 152819.01 | 1.51% |
| ICEX, Mumbai | 85664.19 | 0.85% |
| ACE, Mumbai | 46756.74 | 0.46% |
| UCX, Mumbai | 73013.19 | 0.72% |
| MCX, Mumbai | 8611449.07 | 85.13% |

Source: Forwards Market Commission, Annual Reports.

MCX has emerged as the largest commodity futures exchange comprising a 85.13-percent share of the commodity market in India This is followed by NCDEX with a 11.33-percent share. The total value of trading at the commodity exchanges during the year 2013-14 has been Rs. 1, 01, 44,794.98 crores. Gold, Silver and Crude Oil accounted for highest share in MCX, while in NCDEX, Soya Oil, Soya bean and Castor Seed and in NMCE, Raw Jute, Castor Seed and Mustard Seed were the most actively traded commodities. Even though there are 17 commodity exchanges operating in India, MCX, NCDEX, NMCE and NBOT together contribute more than 98 percent of the market. The Indian commodity market has shown tremendous growth in terms of both value and the number of commodities traded for the past five years.

**Figure 2: Major Group of Commodities traded during the Year 2013-14**




The most important reason for the rising trade volumes on the Indian commodity futures exchanges is that they provide an efficient platform for hedging against price uncertainty and global volatility. The exchanges provide transparent price discovery and hedging platform for trading futures contracts of different commodities. On these exchanges, the fair value price is determined through active participation of a large number of stakeholders of the commodity value chain. Specifically who have access to information on the demand and supply condition. The Indian commodity exchanges have witnessed a sharp surge in trade volumes and turnover in recent years. Consequently, the stakes are higher than ever before. Investment in commodity futures is now serving as a noticeable alternative to traditional investments in stock markets. Further, with a progressive FDI policy for commodity markets on the raise, investor prerequisites include transparency and assurance on the enforcement of future contracts. While the FMC serves as a regulatory body, the exchange defines its own day-to-day functioning, which encompasses setting the norms of trading and settlement, insuring adequate arrangement for surveillance and following the best practices for risk management, which are premeditated to be in line with international standards. The growth can be attributed to the following factors that include larger participation in the market by distinct entities, increase in global commodity prices, the introduction of new commodity exchanges and the reinstating of trade in some of the suspended agricultural commodities.

In India, various legislations such as Forward Contract (Regulation) Act (FCRA), 1952; Essential Commodities Act (ECA), 1955 and Prevention of Black-Marketing and Maintenance of Supplies of Commodities Act, 1980 regulates the trading, stockholding and merchandising of commodity futures. The FCRA, 1952 envisages a three-tier regulation for commodity futures trading in India. These include (i) an association recognised by the Government of India on the recommendation of the FMC, (ii) the FMC and (iii) the central government. As per the act, the exchange that organises forward trading in regulated commodities can prepare its own rules (Articles of Association) and bylaws and regulate trading on a day-to-day basis. The FMC approves these rules and byelaws and provides a regulatory overview. The ECA, 1955 came into powers to control the production, supply, distribution, etc. of essential commodities for maintaining or increasing supplies and for equal distribution and availability of commodities at fair price. Using the powers under the ECA, 1955, various departments of the central government have issued control orders for regulating production, distribution and quality of products, movements, etc. pertaining to the commodities that are essential and administered by them.

FCRA, 1952 governs all types of forward contracts in India. Based on the extent of regulation, the act categorises commodities into three groups: (i) the commodities in which futures trading can be organised under the auspices of a recognised association (ii) the commodities in which futures trading is prohibited (iii) the free commodities which are neither regulated nor prohibited. However, FCRA, 1952 prohibits option contracts in commodities but the ready delivery contracts remain outside its purview. The ready delivery contract is defined as the one that provides for the delivery of goods and payment of a price, either immediately or within a period not exceeding 11 days after the date of the contract. All ready delivery contracts where the delivery of goods and/or payment for goods is not completed within 11 days from the date of the contract are defined as forward contracts and are under the purview of FCRA.

The act classifies forward contracts into two categories, specific delivery contracts and futures contracts (non-specific delivery contracts). Specific delivery contracts are the forward contracts that provide for the actual delivery of specific qualities or types of goods during a specified time period at a price fixed thereby or to be fixed in the manner thereby agreed and in which the names of both the buyer and the seller are mentioned. Specific delivery contracts are of two types as transferable and non-transferable. The distinction between the transferable specific delivery (TSD) contracts and non-transferable specific delivery (NTSD) contracts is based on the transferability of the rights or obligations under the contract. As per section 15 of the act, every forward contract in notified goods (currently 36 commodity items), which is entered into except those between the members or through the members of a recognised association, is treated as illegal or void. As per the section 17(1) of the act, 82 items are prohibited from entering into forward contracts. Section 18(1) of the act exempts NTSD contracts from regulatory provisions. However, over the years, regulatory provisions of the act were applied to the NTSD contracts, and 79 commodity items are currently prohibited from NTSD contracts under section 17 of the act. Moreover, another 15 commodity items have been brought under the regulatory provisions of section 15 of the act, out of which trading in NTSD contracts has been suspended for 12 items. At present, the NTSD contracts in cotton, raw jute and jute goods are permitted only between, through or with the members of the associations specifically recognised for the purpose.

The Forward Contract Regulations Act (1952) has been amended over the years. Various committees have worked on and reshaped the act in varying capacities. An example is the Kabra Committee in 1993, which proposed strengthening of the FMC and a few amendments to the Forward Contracts (Regulation) Act, 1952. The major amendments included allowing options in goods, increase in outer limit for delivery and payment from 11 days to 30 days for the contract to remain as a ready delivery contract and registration of brokers with the FMC. The government accepted most of these recommendations and futures trading have been permitted in all recommended commodities except bullion and basmati rice.

The FMC has imposed several regulatory measures that are implemented in developed markets such as daily mark to market margining, time stamping of trades, innovation of contracts and creation of a trade guarantee fund, back- office computerisation for the existing single commodity exchange and online trading for the new exchanges, demutualisation for the new exchanges, one-third representation of independent directors on the boards of existing exchanges, etc. Though these measures were intended to promote financial integrity, market integrity and transparency, most of these have met with strong resistance from the trade. The exchanges, therefore, had to be virtually forced into adopting some of the measures by the regulatory dictate. The exchanges have attributed the subsequent fall in the volume of trade to the introduction of these measures. Exchanges such as the Bombay Commodity Exchange and Kanpur Commodity Exchange, which implemented most of these reforms, were literally deserted by all traditional players.

The government has taken a landmark decision to deregulate long duration margining contracts (non-transferable specific delivery contracts) from the purview of the Forward Contracts (Regulation) Act, 1952. There is a need for radically reducing the negative list of commodities in which futures trading is not allowed. The reasons, whether right or wrong, which led the government to ban a large number of commodities no longer exist today. Prior to 1960, futures trading used to be conducted in traditional commodities at the conventional places of trading as per the set terms and conditions. When futures trading in these traditional commodities was prohibited, either non-transferable specific delivery contracts or futures trading in the commodities of minor nature which had no tradition of futures trading were used as a guide for conducting futures trading in traditional commodities. Most of these minor commodities were included in the negative list to prevent such disguised trading. Now that most of these conventional commodities such as edible oil and cotton are legally allowed, the need for using minor commodities as a camouflage has disappeared.

Secondly, futures trading can generally be conducted only in commodities, which have competitive markets. It is necessary that the market forces of demand and supply largely determine the prices. India has already made a transition from being a food importing country to a food surplus country. The Government will have to substantially dilute the administered price mechanisms and integrate the internal food grains market with the global markets. The shortage conditions have changed, in addition to the perception that futures market is volatile, aggravating the impact in a shortage situation. It is appreciated in the policy circles that even in a shortage situation, futures market help to balance the demand for the commodity and has a salutary impact of reducing intra-seasonal price-spread.

The integration of the spot and futures markets is another critical factor for the growth of commodity futures in India. The spot market in commodities is controlled largely by the state governments. There are restrictions on stockholding, turnover and the movement of goods. Variations exist in the duties levied by the different state governments. This fragments the commodity spot markets and hinders the commodity futures markets from reaching the market players outside the boundaries of the states or zones in which the exchanges are located.

Despite these largely uncontrollable factors causing fragmented spot markets, it is necessary to address other issues that contribute to this fragmentation. The commodity prices are influenced by various factors like quality, grade, production cycles, the quality of storage and warehousing, etc. Like commodities, securities are not available in different grades and qualities. As commodities are bulky, they are difficult to store & transport, which affect spatial integration. These issues can be addressed by introducing a nation-wide warehouse receipt system.

Under the warehouse receipt system, the warehouses which meet the prescribed standards of storage, preservation, testing, grading and certification would be licensed by the Central Regulatory Authority and the warehouse receipts issued by these warehouses would become negotiable. The Central Regulatory Authority would evolve the system of inspection, monitoring and surveillance to ensure that the licensed warehouses comply with the prescribed standards and warehouse receipts issued by them truly reflect the quality, quantity and ownership of the goods. Commodity exchanges could create a marketplace for trading and settlement of warehouse receipts to facilitate hassle-free trading in commodities. This would improve the collateral value of the goods and consequently, the credit flow to the commodity sector, obviating the need for distress sale by farmers and even by some mills, who/which do not have the waiting capacity due to inadequate liquid assets necessary for meeting the immediate consumption/working capital needs.

## 3.3 INDIAN COMMODITY FUTURES: INVESTORS' PERSPECTIVE

Commodities have garnered considerable attention in recent years. This has been a function of the explosive growth in the developing world, most notably in China and India, as these nations that have emerged as voracious consumers of commodities, surpassing even the U.S. in certain instances. Although India has to cover a long distance to be able to harness the potential in many commodities, it has substantial opportunities to develop consumer demand and uncover latent consumption. Despite having significant benefits, commodities trading have been limited to large companies, trading houses and high net worth individuals (HNIs). The key reason that discourages the retail investors from actively participating in commodities trading is lack of familiarity.

Moreover, the current tax regime is not favourable for investors. Finally, there are various issues at institutional and policy-levels, associated with commodity exchanges that remain unaddressed by the government. It should coordinate with FMC so as to take necessary measures to pave the way for a significant expansion and will lead to further development of the commodity futures markets. Additionally, the focus on environmental issues have added to the debate over the world's limited resources, and with it, greater awareness of the commodity markets that improved alongside the traditional capital markets.

Commodities are available to investor for investment in various options, physical commodity, commodity futures, commodity related stocks or mutual funds. The practical problems associated with investing in physical commodities are well known, commodities must be stored and delivered, and are illiquid. As a result, the vast majority of investment in commodities is through the futures markets. Commodity futures do not represent direct exposure to actual commodities. They rather depend on the expected future spot prices of the underlying commodities. These markets exist in part because it is often in the best interests of commodity producers to lock-in prices in advance of production and delivery to market, and therefore, those producers must incentivize speculators to assume the price risk. As an example, if a farmer believes that corn prices in the fall will be 405 cents per bushel, that farmer might be willing to enter into a contract today to sell corn harvested at that future date for 380 cents per bushel. The farmer then locks in the selling price and the buyer of the futures contract locks in an expected risk premium of 25 cents. But in doing so, assumes the risk of adverse price movements. Unexpected price increases add to the speculator's return, whereas unexpected declines in price subtract from the speculator's return. So as long as the spot price follows the expected trend, those trends are not a source of return to investors; investors in commodity futures can make money even if the trend in spot prices is down. Investing in commodity related stocks or mutual funds, exposes the investor to management specific risks. Therefore, this study unveils the asset like properties of commodity futures for a risk-averse investor.

Gary Gorton (2004) of the University of Pennsylvania and K. Geert Rouwenhorst of Yale University, entitled Facts and Fantasies about Commodity Futures, the historical risk premium earned by investors in futures contracts has been about 5%, which coincidentally is about the same as the historically observed excess return to stocks over bonds. Messrs. Gorton and Rouwenhorst also found that the average annualized return to a fully collateralized (i.e. unlevered) investment in an equally weighted index of commodity futures has been comparable to the S&P 500 (10.8% vs. 10.5%) since 1959. Their findings were further supported by a study commissioned in 2006 by PIMCO and conducted by Ibbotson Associates, covering the years from 1970 to 2004. The study found that the composite commodity index used in the study produced the highest historical return among the asset classes considered. This also included Treasury bills, TIPS, U.S. bonds, international bonds, U.S. stocks and international stocks.

So the return potential of commodity futures, at least historically and internationally, has been sufficient to warrant inclusion in a diversified portfolio. But that return potential does come at a cost; volatility of an equally weighted commodity futures index has been similar to that of the S&P 500, with large declines from time to time. Investors should assume that commodities will continue to exhibit equity-like risk. The final consideration in determining the proper role for commodities in a diversified portfolio is the correlation between commodity returns and those of stocks and bonds. Gorton and Rouwenhorst found that over all horizon periods (except monthly), the correlation between equally weighted commodity futures and other asset classes is negative, and with increase in the holding period, the negative correlation increases. Ibbotson also found that commodities have had a very low average correlation to other asset classes and a positive correlation to inflation, thus offering substantial diversification benefits.

A commodity futures market (or exchange) is a public market where commodities are contracted for purchase/ sale at an agreed price for delivery on a specified date. This purchase or sale of commodities should be made under the terms and conditions of a standardised futures contract through a broker who is a member of an organised exchange.

The gradual evolution of commodity markets in India is of great significance for both the country's general economic prosperity and the financial sector in particular. From an investment point of view, commodities can be considered as an alternate asset class. Investing in commodity futures is attractive to investors as commodities have significantly lower degree of association with other traditional asset classes and act as an effective hedge against inflation. Besides being a unique hedging instrument, commodities also provides for efficient portfolio management arising from the diversification benefits, which result in improved returns to domestic as well as international investors.

The commodity futures market provides the means to transfer the risk from producers and consumers of commodities to speculators who have no direct commercial interest in the commodities themselves. Producers' hedge their price risk by taking short positions in future contracts on the commodity that they produce. A similar hedge requires consumers to seize long positions in the futures contracts on their consumption commodities. On the contrary, arbitrageurs and speculators choose to take either long or short positions on a commodity futures contract based on their market perception. The scope of investment by the retail investors' is the thought behind this research, that tries to divulge the potential of commodity futures as an alternative asset for an Indian risk-averse investor.

# CHAPTER-4

# RESEARCH DESIGN

## 4.1 OBJECTIVES OF THE STUDY

Commonly accepted benefits of commodity futures as risk diversifier includes the equity-like return of commodity, as an inflation hedge and the low transaction costs involved in the futures trading. These facts have been well received by commodity marketers and are at the root of most commodity sales pitches. This research adds to the understanding by analyzing the short and long term relation between commodity futures and traditional assets, such as equities and fixed income securities for Indian capital market. It is well-known that the decision to include an alternative asset class to a traditional portfolio for diversification does not depend only on the temporal risk-return characteristics but also on how it correlates with the other assets in the portfolio over time. On a specific note, this research addresses the following objectives:

1. To study the structure of Indian Commodity Futures Market
2. To have retrospective view of the Indian Commodity Futures Market
3. To investigate the use of commodity futures in diversified portfolio as an asset class by analysing the following:
   I. Spot and Future market relationship
   II. Indian commodity futures and Stock market relationship
   III. Indian commodity futures and Bond market relationship
   IV. Commodity futures as an inflation hedge

In order to justify that commodity futures enhance the performance of traditional portfolio, a paper portfolio is constructed to analyse the returns associated when we include and without the inclusion of commodity futures.

## 4.2 HYPOTHESES

The hypotheses are framed so as to study the asset properties of commodity futures. In order to achieve the objective, the first hypothesis would determine the difference between the commodity futures and commodity spot prices. In second hypothesis, the study determines the short and long term relation of commodity futures with equity and bond. If commodity futures does not move in sync with equity and bond, then on including an uncorrelated asset to the portfolio would improve the portfolio performance. The third hypothesis determines whether commodity futures provide diversification against inflation and lastly, the fourth hypothesis verifies whether the allocation of commodity futures remains same at various risk aversion levels of investor. Accordingly, the hypotheses framed to attain the objectives of the study, are as follows:

***Hypothesis 1***

***H01:*** *There is no significant difference between returns of commodity futures and commodity spot market.*

***H11:*** *There is a significant difference between returns of commodity futures and commodity spot market.*

***Hypothesis 2***

***H02:*** *There is no significant difference among price movement of commodity futures, equity and bond.*

***H12:*** *There is a significant difference among price movement of commodity futures, equity and bond.*

***Hypothesis 3***

***H03:*** *There is no significant correlation between commodity futures and inflation.*

***H13:*** *There is a significant correlation between commodity futures and inflation.*

***Hypothesis 4***

***H04:*** *The allocation to commodity futures in the portfolio does not change with the change in risk aversion levels for maximizing the utility.*

***H14:*** *The allocation to commodity futures in the portfolio changes with the change in risk aversion levels for maximizing the utility.*

## 4.3 DATA

The daily prices for asset classes from Indian Capital market, viz., Commodity futures (MCX COMDEX), Commodity Spot (MCXSCOMDEX), Equity (S&P CNX Nifty), Bond (NSE G-Sec), and T-bill (NSE TB Index) and monthly data for WPI are examined for the period June 2005 to December 2011 to determine the diversifying properties of commodity futures.

**Commodity Futures**: MCX COMDEX- It is designed & developed by the Research & Planning Department of Multi Commodity Exchange of India Ltd. (MCX) in association with the Indian Statistical Institute (ISI), Kolkata. This is the composite commodity index in India based on commodity futures prices. The MCX COMDEX is the simple weighted average of the three group indices - MCX AGRI, MCX METAL & MCX ENERGY, which are computed on the basis of geometric mean. The weighting approach of MCX COMDEX relies on both the endogenous and exogenous factors of futures market that includes liquidity and market size of the exchange.

**Commodity Spot:** MCXSCOMDEX- This index is constructed by using the current spot prices for MCXCOMDEX.

**Equity**: S&P CNX NIFTY Index- It is a well diversified 50 stock index representing 22 sectors of the economy. This index is used as benchmark for fund portfolios, index based derivatives and index funds. S&P CNX Nifty is owned and managed by India Index Services and Products Ltd. (IISL), which is a joint venture between NSE and CRISIL. About 67.27% free float of stock market capitalization at NSE is represented by S&P CNX Nifty Index. The study uses the Total Return Index (TRI) prices for the analysis. TRI reflects the return arising from the stock price movements and also from the dividend receipts from the stocks that form the index.

**Bond**: NSE G-Sec. Index – with maturity period of more than 8 years. This index prices does not include NSE Benchmark Zero Coupon Yield Curve (ZCYC). So that movements in the index prices reflects the change in interest rate to the investors and not the impact of idiosyncratic factors. The constituents in the index are weighted by their market capitalization. This index is computed using arithmetic and not geometric calculations. The index uses a chain-link methodology i.e. today's value is based on the previous value times the change since the previous calculation. This gives the index the ability to add new issues and also remove old issues when redeemed. The index quotes the dirty price, which includes the accrued interest also.

**T-bill:** NSE TB Index – 30day T-bill return from NSE.

**Inflation:** WPI is the measure taken for inflation and the data is collected from the Office of the Ministry of Economic Affairs, Government of India.

Daily data was preferred as against the monthly data because any transmission mechanism between the stock markets in the ECM is most likely to occur within few days. However there are certain drawbacks in using the daily data in time series such as the occurrence of Autoregressive Conditional Heteroskedasticity (ARCH) in the residuals. In ARCH, the variance of the residuals in one period is dependent on the variance of the residuals in the previous period. To eliminate heteroskedasticity in the residuals, the data can be computed into monthly series. The results were also verified using monthly data. However, the ARCH processes of the residuals were not eliminated. The estimation results obtained by using the monthly series were generally the same as the results obtained from daily data (Appendix A). The results in Appendix A shows that whether the data is daily or monthly time series, the cointegration results remain same for the two time series. Secondly, the daily data in financial time series suffers from representation bias from thinly traded instruments; however, this problem does not occur in the present study as the data is collected for the market indexes, which are highly liquid instruments. In all, since the results obtained using monthly or daily data was same, using the data that is not subject to liquidity problems, and the necessity to have as many observations as possible to build portfolios, the daily observations – index prices at the closing values of the day, were preferred over the monthly series.

All the data points related to equity, bond and commodity futures were matched date wise so as to build a compendium of data that is uniform throughout. Finally, the study is conducted from perspective of an Indian investor who is a risk averse investor with an objective to assess the diversifying properties of commodity futures to reduce the risk and improve the return to traditional portfolio.

## 4.4 RESEARCH TECHNIQUES

The study provides detailed empirical evidence on the extent to which the prices of commodity futures and other classes move in sync so that the investor is able to take better investment decisions. The study takes the perspective of a passive investor when analyzing the relationship between commodity futures and other asset classes. Modern portfolio theory suggests that the information required for a passive investor to include an alternative asset is the expected return, the variability of these returns and cross-asset correlations with the existing assets in the portfolio (Buyuksahin et al., 2010).

Strategic asset allocation is one of the most important set of decisions for a portfolio manager. Asset allocation is the amount of exposure (positive or negative) to a certain class of asset in the portfolio. Before doing the asset allocation the first step is to decide on the types of asset to be included in the portfolio. The theory says that an asset that has low or negative correlation with other assets existing in the portfolio should be included. But correlation being a short term estimate; the key issue for an investor is how to consider the long term movements between the asset prices (Kasa, 1992). In standard risk –return models, any long term trends in the data is removed by differencing the prices of the assets. Although these trends are implicit in the returns data, but then these risk-return models does not include the decisions based on long term common trends in the price data (Alexander, 1999). To incorporate this long term impact in portfolio construction, the study uses co-integration technique developed by Johansen (1988, 1991, 1992b) and Johansen and Juselius (1990) to test the long term co-movement of commodity future prices with equity prices.

Correlation and co-integration although related, are two different concepts. Correlation having a short term implication reflects co-movements that are liable to instabilities over time. So, correlation based portfolio strategies require frequent re-balancing. In contrast, co-integration measures long run co-movements in prices that may occur even through periods when static correlations appear low. The high correlation of returns does not essentially imply high co-integration in the prices (Alexander, 1999). Thus, diversification decisions based on co-integrated assets may be more effective in the long term. By including the assets that are not co-integrated would result in a more effective portfolio that does not require frequent re-balancing of the portfolio. While constructing a portfolio, high correlation among assets cannot be taken as a sufficient measure for long term diversification benefits, there is a need to enhance the standard risk-return modelling methodologies to take account of common long term trends among the asset prices. To complement this, the research extends the traditional models by including a preliminary stage in which the asset prices are analyzed, and then augments the correlation analysis to include both short term and long term dynamics.

Moreover, there are very bright chances that with the inclusion of leads or lags in the time series data, the results of correlation analysis get altered. For example, on lagging some of the daily time series by one or two days, the correlation might even turnaround with correlation coefficient being significant (Balarezo, 2010). Furthermore, the effect of correlation on the common long term relationship between the series will be minimal. However co-integration permits that the two time series in the short term may diverge, meaning that the series does not have to necessarily move in the same direction. But in the long run, the series cannot drift away in the opposite direction for very long and will come back to their long term equilibrium. As a result, co-integration is a better predictor of long term relation between the two variables as compared to correlation.

The distinction between stationary and non stationary time series is extremely important because stationarity is a precondition to make statistical inferences. On applying the regression on the non-stationary time series, where mean and variance does not remain constant with time, the results generated cannot be generalised from one time period to another time period (Alexander, 1999). So, it becomes necessary to identify if the time series are stationary or not, before any statistical inference could be made.

On performing regression analysis on time series when, both the dependent and independent variables follow a unit root process, the results will have no economic significance. In particular, the estimates will be biased and hypothesis tests will be invalid. This is the problem of spurious regression which was first reported by Yule in 1926. In order to confirm the (stationary) nature of the series, Augmented Dickey-Fuller test is performed under the unit root test to identify whether or not the series is stationary. To analyze long-term co integration, the daily settlement prices for all the indices are used. Visual inspection of the series is done using graphical representation so as to have a general approximation of the evolution of time series.

Our study of testing whether there is a long-run statistical relationship between commodity futures and other assets depend on the methods of Johansen's co-integration analysis. The idea for the analysis is that if two series each follow upward trend, then, in general, they will diverge in the long run. Our approach of identifying the long run relationship between the asset prices comprises of four parts: (1) testing for a unit root in each price indices, (2) testing for the number of co-integrating vectors in the systems of asset prices, provided the null hypothesis of a unit root for every price index is not rejected, (3) testing the vector auto regression between the assets, and (4) testing the causality effect among the two assets.

Now, once the short and long run relationship is identified among the variables, the next step would be the construction of optimal portfolios. The benefits of commodity futures investments are examined by making a paper portfolio using optimal portfolio strategy within a mean variance framework and also determining how an investor's investment policy changes when the objective function is to maximize expected utility. The diversifying properties of commodity futures are analyzed using daily average return, standard deviation (SD), Sharpe ratio and correlation coefficients for all the asset classes. To complement the diversification properties, the movement of all assets with inflation is also considered.

**Test of Stationarity**

An examination of whether a series is stationary or not is essential for two reasons, first the stationarity of the series can influence its behaviour and properties and secondly, non-statonarity can lead to spurious regression (Brooks, 2008). The first step of the analysis is testing the unit root for each price index at its levels, and if it is found to be non stationary, then the price index is differentiated and again checked for the stationarity. This is done in order to determine the order of integration, which is the number of times the price indices are differentiated to make them stationary. All the price indices should be integrated of the same order so as to determine the co-integration among the variables. If a series is stationary I(0), meaning that the data is stationary at levels, then co-integration will not yield significant results. In the same way, any variable is I (2), a co-integration test could not be performed against a series that is I(1). Therefore, before implementing the cointegration analysis, the stationarity of the all the series is tested using Augmented Dickey Fuller (ADF) test.

The concept of stationarity can be understood from the following. An Autoregressive model AR (p) is defined as a model where the independent variable (explanatory variable) is the lagged values of the dependent variable. If there is only one lag for independent variable, then it is an AR (1) model like in equation (1).

$$Xt = a + \rho Xt - 1 + et$$

*[Equation # 1]*

A time series like equation (1) is said to be stationary if it satisfies the following three conditions:

i) **Constant and finite mean:** The condition where the expected value of the series is constant over a time period. In this condition, a series has a tendency to move back towards its mean value, that is, it exhibits the property of mean reversion. In other words, it will have a tendency to decline if its current value is above its mean, and will tend to increase if its current value is under its mean. For a time series like equation (1) the mean reverting level is expressed as:

$$(Xt)= (1-\rho)$$

ii) **Constant and finite variance:** In this condition, volatility of the time series around its mean does not change over time. This can be expressed as:

$$Var\ (X) = \sigma 21-\rho 2$$

iii) **Constant and finite covariance with leading and lagged values:** Under this condition, the covariance of time series is constant over time with its own leading or lagged values and is expressed as follows:

$$Cov\ (\ ,-s)= \rho s* \sigma 21- \rho 2$$

In other words, the covariance between leading or lagged values does not depend on time (t), but depend only on s (the distance between periods). If a time series does not have the above three characteristics, it is called a non stationary time series.

For a series to be stationary, the above three equations would be satisfied only in the case when $| \rho | < 1$. While if $| \rho | > 1$, the series is said to be explosive, meaning that future values will not get back to the mean value but rather will diverge at a faster, almost exponential pace every subsequent period. If $| \rho | = 1$ then the mean reverting level is undefined (divided by 0), and in this particular case the time series is not covariance stationary and exhibits the property of unit root (Balarezo, 2010).

A random walk (RW) process is an example of a time series that exhibits a unit root. This means that the expected value for the series in the next period (t+1) is equal to the value of the series the previous period (t) plus a random error term. Because the difference in the series between one period and the next period is a random number, the data cannot be modelled unless it is transformed. In other words, reliable inferences cannot be drawn from the Ordinary Least Square (OLS) procedure. If a series exhibits unit root property, the results achieved would be incorrect unless the data is transformed before statistical procedures are performed.

Once the variables are identified as non-stationary variables, the data is transformed to a stationary process. Before transforming a non stationary time series to stationary, the different types of non stationary processes should be defined.

There are basically three types of non stationary time series: (i) series with stochastic trends called random walks – with drift and without drift, (ii) series with deterministic trends, and (iii) series with a combination of stochastic and deterministic trends. Summarily, these can be explained as follows:

i) **Random walk without drift:**

$$Xt = Xt-1 + et$$

*[Equation # 2]*

Where the E $(Xt)$ = $X0$ and Var (Xt )=t σ2.

This kind of process has no intercept, which implies that the best forecast that can be achieved today with respect to future stock prices is the same price as today price plus or minus a random, unpredictable value. As the variance depends on time (t), the process is said to be non stationary.

ii) **Random walk with drift:**

$$Xt = a + Xt-1 + et$$

*[Equation # 3]*

Where E $(Xt)$ = $X0 + t*a$ and Var (Xt )=t σ2

This process is different from the earlier as this equation includes an intercept term, which is called drift and makes the process drift upwards or downwards, depending on the sign. Since, $E(Xt)$ and variance of the process are time dependent, the process is non stationary.

iii) **Deterministic trend:** The random walk processes have a trend that is totally unpredictable, and thus they are implied to contain a stochastic trend. In other cases, the trend in the process is a function of time and is therefore totally predictable. This kind of time series where the independent variable is just the passing of time, are called trend stationary process and can be expressed like:

$$Xt = a + bt + et$$

*[Equation # 4]*

Where $E(Xt) = a+bt$ and Var (Xt )=σ2

It is clear that the $E(Xt)$ depends on time t and thus the process is non stationary, showing that the mean of the data grows around a fixed trend.

iv) **Random walk with drift and deterministic trend:**

$$Xt = a + \rho Xt{-}1 + bt + et$$

*[Equation # 5]*

In this case, an AR(1) process is combined with a deterministic trend. Even if the AR part of the process does not contain a unit root, i.e. $| \rho | < 1$, the series will still remain non stationary because of the presence of the deterministic trend. Whereas, the series will be stationary around a deterministic trend, i.e. the stochastic part of the process will not contribute to the trend of the process but will rather die out quickly. The trend is explained by the t term.

If the series contain a unit root, such as in equations (2) and (3), it can be transformed into a stationary time series by applying the differencing method, which involves subtracting the value of the dependent variable in the preceding period from its current value to define a new dependent variable $\Delta Xt = Xt - Xt{-}1$. For our simple AR (1) model in equation (1), the first differencing will transform the series into:

$$Xt - Xt{-}1 = a + \rho Xt{-}1 - Xt{-}1 + et$$

But as the original series contain a unit root ($|\rho|=1$), then: $\Delta Xt = et$

It has been previously mentioned that the mean reverting level is: $(1-\rho)$ and it is easy to see that the transformed series will have a finite mean-reverting level (i.e. a/1 for the case of a random walk with drift, or 0/1 = 0 for the basic random walk process). If a series that is non stationary becomes stationary after differencing, the series is said to be integrated of order p, that is, if the series is differenced only one time before it becomes stationary, then the series is integrated of order 1, or I(1).

**The ADF test for unit roots**

The Augmented Dickey Fuller (ADF) Test is used for testing if a series has a unit root or not. This is an extension of the regular Dicker Fuller Test (DF). First, the DF test is explained and then the ADF test is discussed.

The DF test checks if a unit root is present in an AR(1) equation like:

$$Xt = \rho Xt{-}1 + et$$

*[Equation # 6]*

To do that, it subtracts $Xt{-}1$ from both sides of equation (6) to obtain:

$$Xt - Xt{-}1 = \rho Xt{-}1 - Xt{-}1 + et\Delta Xt = (\rho-1)\, Xt{-}1 + et$$

$$\Delta Xt = \delta Xt{-}1 + et$$

*[Equation # 7]*

From equation (7), if the estimated that $\delta = 0$, then $\rho$ will be 1, implying that the time series in equation (6) has a unit root and that $Xt$ is non stationary. If $\delta < 0$, then $\rho < 1$ and $Xt$

is stationary. Similar to the characteristics of non stationary processes, that they might have no drift, a drift, or deterministic trends, there are three different specifications for the DF test:

Test for Random Walk (RW):

$$\Delta Xt = \delta Xt - 1 + et$$

*[Equation # 8]*

Test for Random Walk with Drift (RWD):

$$\Delta Xt = a1 + \delta Xt - 1 + et$$

*[Equation # 9]*

Test for RWD and Determinist Trend:

$$\Delta Xt = a1 + a2t + \delta Xt - 1 + et$$

*[Equation # 10]*

It is important to know which among the three specifications, is the most suitable for the times series that is being analyzed. Campbell and Perron (1991) discussed the problem of correct specification of the deterministic component and intercept. They showed that an incorrect exclusion of the intercept or deterministic time trend term leads to bias in the coefficient estimate for δ. For example, if the time trend term is inappropriately excluded (i.e. on using equation 9 instead of equation 10) then the power (probability of correctly rejecting the null hypothesis) of the unit root test can be substantially reduced. This will help in observing a trend, which may be captured through the random walk with drift model. In most cases, there is no way to know which specification is correct, so it is recommended to do sequential testing with the different specifications. In this case, dealing with series that seem to drift upwards, specification equation 8 is eliminated, so test specifications equations 9 and 10 will be tested. If both specifications show the same results (i.e. that the series has or not a unit root) then the results will be confirmed.

The null hypothesis is the same in all cases: $H_0$: $\delta = 0$, equivalent to say that $\rho = 1$ or that the time series is non stationary. The alternative $H_1$ is: $\delta < 0$, or that the series is stationary. To conduct the test, the t-statistics are calculated in the conventional manner, but the critical values to compare are not the critical values for the t-test, but a set of critical values computed that follow a tau statistic ($\tau$) distribution known as the Dickey Fuller tables. It is important to notice that the critical values from the Dickey Fuller tables are different for each of the three specifications (Balarezo, 2010).

The ADF test is developed from the basic DF test. While the DF test does not test for autocorrelation on the residuals ($et$), the ADF removes any autocorrelation by adding the lagged values of the dependent variable $\Delta Xt$ to equations (8) to (10). Lagged values are added empirically until the error term has no autocorrelation. The ADF regression to estimate unit root is:

$$\Delta Xt = a1 + a2t + \delta Xt-1 + \Delta Xt-1 + \Delta Xt-2 + \ldots + \mu t$$

*[Equation # 11]*

Where $\Delta Xt-1 = Xt-1 - Xt-2$ and $\mu t$ is pure white noise.

A drawback in using DF test for identification of unit root is that it for border line cases, the test tends to find a unit root when there is none. In other words, a ρ value close to one (say 0.90) could be mistakenly confused as a unit root process by the DF test.

After identification of whether our series have unit roots, the first difference is taken ADF test on the differenced series is performed to see if it becomes stationary. This process is necessary because, as mentioned before, co-integration results between two non stationary series are only valid if the integration of said series is of the same order. Once it is determined that our series are integrated of the same order, co-integration tests can be performed.

**Test of Long Term Co-movement**

To test the long term relationship among the stationary variables, the co-integration methodology is used. Co-integration can be defined in the following way: if two series are individually non stationary, but a linear combination of them is stationary, then the two series are said to co-integrate, or that a long run equilibrium relationship exists between them. A co-integrating relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that co-integrating variables may deviate from their relationship in the short run, but their association would return back in the long run (Brooks, 2008).

Katarina Juselius (2006) defines the role of co-integration analysis as, co-integration identifies stationary linear combinations between non stationary variables so that an I (1) model can be reformulated exclusively in stationary variables. Co-integration allows the modelling of two series that otherwise could not be modelled because of the individual non stationary properties on them.

Bi-variate co-integration tests will be carried out between commodity futures and other asset classes. Even though a co-integration test is performed, the goal is to find assets that do not co-integrate with the commodity futures so as to provide an alternative asset for Indian investor to diversify the portfolio. There are two widely used tests for identifying the co-integration- the Engle Granger test and the Johansen test.

**The Engle Granger test**

The Engle Granger test is a two step process where the first step consists of regressing Y on X on two series that are of the same I(p) process.

$$Yt = \alpha_1 + \alpha_2 Xt + \varepsilon t$$

*[Equation # 12]*

In the second step, the residuals from the above equation are used to perform a unit root test on them. If the $H_0$ of unit root cannot be accepted, then the residuals are stationary and it can be concluded that Y and X co-integrate. In this case equation (12) is a co-integrating equation where $\alpha_2$ represents the long run equilibrium between X and Y.

The Engle Granger Test has a few drawbacks. First, it is a unit root test on the residuals and another drawback is that the test requires defining the dependent and independent variables to find the equilibrium relationships. It is feasible however, that one regression will find an equilibrium relationship while reversing the variables will not find co-integration. This is highly undesirable because long run relationships should be invariant of which variable is chosen to be the dependent one. Lastly, the test only confirms if there is a common long term equilibrium relationship between the variables, but it does not tell how many co-integrating relationships exist, as there might be more than one equilibrium relationship. It is because of these downfalls that the Johansen test is a preferred technique for finding long run relations between the variables. The Johansen test is a maximum likelihood ratio that test for various co-integrating relationship between variables.

**The Johansen test**

The Johansen method is used to determine the presence of co-integrating vectors in non stationary time series; it can be applied to a bi-variate or multivariate setting. In the case of a multivariate setting, it has the advantage of finding and providing estimates for all the co-integrating vectors within a Vector Autoregressive Model (VAR).

A VAR (k) model is simply an extension of the AR (p) model, where there is more than one dependent variable under study and thus more than one equation. In the model, each equation has an independent variable as lagged values of all the variables under study. A deterministic trend could also be included in the model. The VAR(k) model is used to find the interdependences between several time series, thus, it is a ‘theory free model’ and it is allowed to find any relationship in between the variables (Balarezo, 2010). A VAR model with ($k$) order has the following representation:

$$Xt = \mu 0 + \delta 0 t + \pi 1 Xt - 1 + \ldots + \pi k Xt - k + \epsilon t \; t = 1$$

*[Equation # 13]*

Where $Xt$ is a (nx1) vector of variables, δ a deterministic trend and ϵt is a White Noise Process.

In a VAR model, consistency of the parameter depends on the constancy of the covariance matrices between the variables, that accounts for the structural changes in the variables. Additionally, testing the White Noise in the residuals is important for statistical inference and economic interpretation. The model assumes that all available information in time t-1 or before is taken into consideration by economic agents to make plans for time t, by incorporating an auto-correlated residual. Some assumptions however are more important than others. Simulation studies have shown that valid statistical inference is very sensitive to violations in some of the assumptions like parameter non-constancy, auto-correlated residuals and skewed residuals. In contrast, simulation is quite robust to other violations such as excess kurtosis and residual heteroscedasticity.

The Johansen method is based on the error correction representation of the VAR, the so called Vector Equilibrium Correction Model (VECM) that reformulates equation (13) in terms of differences, lagged differences and levels of the process to obtain: .

$$\Delta Xt = \Gamma 1 \Delta Xt - 1 + \pi Xt - 1 + \epsilon t$$

*[Equation # 14]*

It can be seen that in equation (14) the left hand side is stationary. Since a stationary variable cannot be equal to a non stationary expression, so the only option is that the right hand side should also be stationary. For this to happen, either π = 0, or it must have a reduced rank. To test the restrictions in π, Johansen defines two matrices α and β, both of dimensions n x r where r is the rank of π and n the number of variables. The properties of α and β are such that: $\pi = \alpha\beta'$

*[Equation # 15]*

(14) can be written as: $\Delta Xt = \Gamma 1 \Delta Xt - 1 + \alpha\beta' Xt - 1 + \epsilon t$

*[Equation # 16]*

For equation (16) to balance, r must be <= n. In this case, $\beta' Xt - 1$ becomes an r x 1 vector of stationary co-integration relations.

In equation (16), β is the matrix of co-integrating parameters and α is the matrix of weights with which each co-integrating vector enters the n equations of the VAR. In other words, α can be seen as the matrix of the speed of adjustment parameters. In this respect, the αij coefficients should have an inverse sign to its correspondent βij indicating that the co-integrating relationship is equilibrium correcting. Generally, there are three cases in the π matrix.

i) If r = n, then Xt is stationary and there is no need to express the system as VECM, standard inferences apply.

ii) If r = 0, there are not co-integrating relationships between the variables, that is the variables have no stochastic trends in common and do not move together over time.

iii) If n > r > 0, there are r co-integrating relationship among the n variables. In contrast with the Engle Granger method, the Johansen method can find more than 1 co-integrating relationship between the variables.

To find r, or the co-integration rank, the Johansen test, often called Trace Test, determines the number of co-integrating vectors in $\pi$ by using a log likelihood function as in equation (17):

$$-2\ (\beta) = T \ln|S00| + T\ \Sigma \ln(1 - \lambda i) pi = 1$$

*[Equation # 17]*

A valid co-integrating vector in $\pi$ will produce a significantly non-zero Eigen Value $\lambda i$. The magnitude of $\lambda i$ indicates the strength of correlation among $\beta' Xt-1$ with the stationary part of the process ($\Delta Xt$) in equation (16).

The trace test does not give the exact number of r co-integrating relations, it only evaluates the $H_0$ hypothesis that the number of co-integrating vectors is less than or equal to r. This is against the alternative that the number of co-integrating relations is higher (r+1). Therefore, the estimation of r implies performing a sequence of tests until it cannot reject the $H_0$ that number of cointegrating vectors <= number of cointegrating relations.

It is important to mention that a constant and a deterministic component could be included in equation (17). They play a significant role in the co-integration model. Therefore, it is important to distinguish between the part of the constant and the trend that belongs to the co-integrating relations $\beta' Xt-1$ and the part that belongs to $\Delta Xt$ in equation (16).

i) **Case 1:** No separate drift in the VECM. - This case corresponds to a model with no deterministic components in the data implying that there are no intercepts in the co-integrating relationships. There are five different specifications of deterministic trends in the VECM form, one of them is:

$$\Delta Xt = \alpha\beta' Xt-1 + \Gamma 1 \Delta Xt-1 + \epsilon t$$

*[Equation # 18]*

ii) **Case 2:** This is a case when in equation (16) only constant term is present in the co-integrating relation and no separate drift. This case is consistent with no linear trends in the data. The VECM equation is:

$$\Delta Xt = (\beta, \beta 0)(Xt-1, 1) + \Gamma 1 \Delta Xt-1 + \epsilon t$$

*[Equation # 19]*

iii) **Case 3:** Drift is present in the VECM but none in the co-integrating relation. This case is consistent with linear trend in the variables that cancel out in the co-integrating space.

$$\Delta Xt = a0 + \alpha\beta' Xt{-}1 + \Gamma 1 \Delta Xt{-}1 + \epsilon t$$

*[Equation # 20]*

iv) **Case 4:** This case represents a linear trend in the co-integrating relation, and an unrestricted constant. This case is consistent when suspected for having trend stationary co-integrating relations.

$$\Delta Xt = a0 + (\beta, 0)(Xt{-}1, t) + \Gamma 1 \Delta Xt{-}1 + \epsilon t$$

*[Equation # 21]*

v) **Case 5:** In this case the quadratic trends are allowed in the model and there are no restrictions in the VECM.

$$\Delta Xt = a0 + \alpha\beta' Xt{-}1 + \Gamma 1 \Delta Xt{-}1 + \delta t + \epsilon t$$

*[Equation # 22]*

The number of lags used in the vector auto-regression is chosen based on the evidence provided by Order Selection Criteria that employs 5 different measures for selecting the optimum lag length. The co-integration procedure yields two likelihood ratio test statistics, referred to as the maximum Eigen Value ($\lambda$-max) Test and the Trace Test, which will help determine which of the possibilities is supported by the data.

The role of co-integration can be well understood by taking an example from the study, i.e, MCXCOMDEX (Commodity Futures Composite Index) and S&P CNX Nifty (Equity Composite Index). It is assumed that both series are I(1), that is they are integrated of the order 1. A regression analysis of these two series is performed to see if there is any relationship between Commodity Futures and Equity. But the results might be spurious in nature. The regression equation will be:

$$CF\ t = a + b\text{Equity}t + et$$

An equation formed by two variables that are individually I(1), would expect the errors to be non-stationary since the error term will just be a linear combination of the other two variables, that is:

$$et = CF\ t - a - b\text{Equity}t$$

However, if the unit roots of both the variables cancel each other, then the error would be stationary, meaning that both variables co-integrate. If that is the case, meaningful statistical inferences can be drawn from the regression of CF on Equity. Furthermore, if there is equilibrium relationship between the two variables, the error term will be small, and it will stay small – because it is stationary – implying that even though each series is trending, there is a long run relationship or equilibrium between them that makes the error term stay stationary .

Co-integration does not imply that the equilibrium relationship is constant, but rather it implies that drift/deviations from the equilibrium should not be too large, and there should be some pulling or pushing force that tries to bring back the system into its long term equilibrium relationship.

If co-integration is not found between the variables, it means that the error term is non stationary - just like the underlying variables in the system - and it will be trending and becoming larger with the passage of time. This implies that deviations from equilibrium will not be brought into a long run steady relationship between the variables. In short, there is no equilibrium relationship between the variables and any result from a regression will be spurious (Balarezo, 2010).

**Model Formation**

If the variables are found to be non co-integrated in the long run, then the next step is to employ vector autoregression followed by the granger causality. The vector auto regression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The optimum lag length is identified using Akaike Information Criteria (AIC). The VAR approach sidesteps the need for structural modelling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system.

Consider two time-series variables, $y_t$ and $x_t$. Generalizing the discussion about dynamic relationships to these two interrelated variables yields a system of equations:

$$y_t = \beta_{10} + \beta_{11} y_{t-1} + \beta_{12} x_{t-1} + v_t^y$$

$$x_t = \beta_{20} + \beta_{21} y_{t-1} + \beta_{22} x_{t-1} + v_t^x$$

The equations describe a system in which each variable is a function of its own lag, and the lag of the other variable in the system.

The vector autoregressive (VAR) model is a general framework used to describe the dynamic interrelationship among stationary variables. So, the first step in time-series analysis is to determine whether the levels of the data are stationary or not. If not, then the series are differenced to determine the degree of stationarity.

If the time series are not stationary then the VAR framework needs to be modified to allow consistent estimation of the relationships among the series. The vector error correction (VEC) model is just a special case of the VAR for the variables that are stationary in their first differences (integrated of I(1)). The VEC can also take into account any co-integrating relationships among the variables.

Consider two time-series variables, and generalizing the discussion about dynamic relationships to these two interrelated variables yields a system of equations:

$$y_1 = \beta_{10} + \beta_{11} y_{i-} + \beta_{12} x_{i-1} + v_i^v$$

$$x_1 = \beta_{20} + \beta_{21} y_{i-1} + \beta_{22} x_{-i} + v_i^v$$

The equations describe a system in which each variable is a function of its own lag, and the lag of the other variable in the system. In this case, the system contains two variables *y* and *x*. Together the equations constitute a system known as a vector autoregression (VAR). In this example, since the maximum lag is of order one, therefore a VAR(1).

If *y* and *x* are stationary, the system can be estimated using least squares applied to each equation. If *y* and *x* are not stationary in their levels, but stationary in differences (i.e., I(1)), then take the differences and estimate:

$$\Delta y_1 = \beta_{11}\Delta y_{i-1} + \beta_{12}\Delta x_{i-1} + v_i^{\Delta v}$$

$$\Delta x_1 = \beta_{21}\Delta y_{i-1} + \beta_{22}\Delta x_{i-1} + v_i^{\Delta v}$$

If *y* and *x* are I(1) and co-integrated, then the system of equations is modified to allow for the co-integrating relationship between the I(1) variables. Introducing the co-integrating relationship leads to a model known as the Vector Error Correction (VEC) model.

Like the VAR, the VECM will have one equation for each variable in the model, but each equation will be an error correction model.

In the case of two variables, Y and X, which have unit roots and are co-integrated, the VECM is:

$$\Delta Y_t = \varphi_1 + \delta_1 t + \lambda_1 e_{t-1} + y_{11}\Delta Y_{t-1} + \ldots + Y_{1p}\Delta Y_{t-p} + \omega_{11}\Delta X_{t-1} + \ldots + \omega_{1q}\Delta X_{t-q} + \varepsilon_{1t}$$

and

$$\Delta X_t = \varphi_2 + \delta_2 t + \lambda_2 e_{t-1} + y_{21}\Delta Y_{t-1} + \ldots + Y_{2p}\Delta Y_{t-p} + \omega_{21}\Delta X_{t-1} + \ldots + \omega_{2q}\Delta X_{t-q} + \varepsilon_{2t}$$

Where $e_{t-1} = Y_{t-1} - \alpha - \beta X_{t-1}$

**Test to check the Statistical Validity of Residuals of the Models**

**Lagrange Multiplier (LM) Test for Serial Correlation:** The LM statistic is useful in identifying serial correlation not only of the first order but of higher orders as well. Here we confine ourselves to the first-order case. The general case of AR (p) is discussed later.

$$y_t = \beta_0 + \beta_1 x_{t1} + \beta_2 x_{t2} + \ldots\ldots\ldots + \beta_k x_{tk} + \rho\varepsilon_{t-1} + u_t$$

The test for ρ= 0 can be treated as the LM test for the addition of the variable $\epsilon_{t-1}$ (which is unknown, and hence one would use $\epsilon_{t-1}$ instead).

If there is serial correlation in the residuals, it is expected, $\epsilon_t$ to be related to $\epsilon_{t-1}$. This is the motivation behind the auxiliary regression in which $\epsilon_{t-1}$ is included along with all the independent variables in the model. The LM test does not have the inconclusiveness of the DW test. However, the LM test is a large-sample test and would need at least 30 degrees of freedom to be meaningful (Gau, 2002).

**Test of Causality**

Granger (1969) introduced a concept of causality in which, a variable y is said to be Granger caused by another variable x if current values of y can be predicted with better accuracy by using past values of x. It can be seen that Granger's concept of causality does not imply an event-outcome relationship, but rather is based on predictability. In other words, the finding that x Granger causes y implies that x has significant incremental predictive power in the evolution of y.

This definition is based on the concept of causal ordering. Two variables may be contemporaneously correlated by chance but it is unlikely that the past values of *x* will be useful in predicting *y*, given all the past values of *y*, unless *x* does actually cause *y* in a philosophical sense. Similarly, if *y* in fact causes *x*, then given the past history of *y* it is unlikely that information on *x* will help predict *y*. Granger causality is not identical to causation in the classical philosophical sense, but it does demonstrate the likelihood of such causation or the lack of such causation more forcefully than does simple contemporaneous correlation (Geweke, 1984). However, where a third variable, *z*, drives both x and *y*, *x* might still appear to drive *y* though there is no actual causal mechanism directly linking the variables. The absence of Granger causality can be tested by estimating the following VAR model:

$$Y_t = a_0 + a_1 Y_{t-1} + \ldots.. + a_p Y_{t-p} + b_1 X_{t-1} + \ldots.. + b_p X_{t-p} + u_t$$

*[Equation # 23]*

$$X_t = c_0 + c_1 X_{t-1} + \ldots.. + c_p X_{t-p} + d_1 Y_{t-1} + \ldots.. + d_p Y_{t-p} + v_t$$

*[Equation # 24]*

Then, testing $H_0$: $b_1 = b_2 = \ldots.. = b_p = 0$, against $H_1$: 'Not $H_0$', is a test that *X does not* Granger-cause *Y*. Similarly, testing $H_0$: $d_1 = d_2 = \ldots.. = d_p = 0$, against $H_A$: 'Not $H_0$', is a test that *Y does not* Granger-cause *X*. In each case, a *rejection* of the null implies there is Granger causality among the variables.

**Portfolio Construction**

This study uses a two stage model of Asset allocation and Capital allocation for portfolio construction as proposed by Bodie, Marcus & Mohanty (2005). The *first stage* of our analysis is asset allocation, where the combination of risky assets that provide the best risk-return trade off resulting in the optimal risky portfolio are determined, using Markowitz portfolio optimization technique. To analyze the diversification benefits of commodity futures, two portfolios, without commodities (A) and with commodities (B) are computed. Firstly, the risk-return opportunities available to the investor in the form of minimum variance frontier of risky assets are determined, using the portfolio SD and expected return as calculated in following equations:

$$V_p = \sum_{i=1}^{k} \sum_{j=1}^{k} [X_i \times X_j \times Cov_{ij}]$$

*[Equation # 25]*

where, $V_p$ = variance of the portfolio return,

$k$ = number of assets in the portfolio,

$X$ = share of asset $i$ or $j$ within the portfolio, and

$Cov_{ij}$ = covariance between assets $i$ and $j$, and is calculated by:

$$Cov_{ij} = s_i \times s_j \times r_{ij}$$

where, $s$ = SD for asset $i$ and $j$,

$r_{ij}$ = correlation coefficient between assets $i$ and $j$.

*The expected return* is determined by:

$$E_{rp} = \sum_{i=1}^{k} [X_i \times E(R_i)]$$

*[Equation # 26]*

where, $E_{rp}$ = return on the portfolio, and

$E(R_i)$ = expected return for security $i$.

A constrained optimization program is run to determine the optimal risky portfolio bounded by the restriction that the exposure in any risky asset is greater than or equal to zero and that the sum of the weights adds up to 1. The quadratic programming is set up to maximize return and minimize variance;

$$\text{Min } z = V_p - Y$$

Subject to:

$$\sum_{i=1}^{k} X_i = 1$$

where, $Y$ = slope of the objective function, and

*Erp* = expected return on the portfolio.

*Y* can be varied from zero to infinity in order to solve for different portfolio points on the efficient frontier. If the weights of assets in the portfolio are less than zero, the resultant portfolio would require short selling of certain assets (Shachmurove, 1998). Therefore, the weights are constrained to be more than or equal to zero, so as to produce short sales constrained efficient portfolio. The result of these portfolios is the efficient frontier, where each portfolio represents the lowest risk for a given return or the highest return for a given risk (Markowitz, 1959). Secondly, to select the optimal portfolio from the set of efficient portfolios, Capital Allocation Line (CAL) is drawn. The point on CAL tangent to the efficient set is the required optimal portfolio. This is also the portfolio that gives the maximum Sharpe Ratio (risk adjusted return). Sharpe ratio measures excess return over unit of total risk and is defined as the portfolio return in excess of the risk free rate, divided by the standard deviation of the portfolio ($= (E_{rp} - R_f)/s_i$ ). A portfolio with a higher Sharpe ratio is preffered to the portfolios with lower Sharpe ratio. For the mean-variance analysis, arithmetic returns are considered more suitable in comparison to geometric returns as it is a better predictor of portfolio performance (Bekkers, Doeswijk & Lam, 2009).

The *second stage* of analysis is the optimal capital allocation between the obtained risky portfolio and the risk free asset. This allocation is determined by the risk aversion level of the investor as well as expectation for the risk-return trade-off of the optimal risky portfolio. When presented with various portfolios of varying degree of return and risk based on numerous asset allocations, an investor would choose a portfolio that would give maximum utility (Anson, 1999). The rate at which investors are willing to trade off the return against risk can be quantified using utility levels. The issue that needs consideration is whether on including commodity futures to a traditional portfolio of stocks and bonds, the utility for the investor also improves. The utility function is given by the following equation:

$$E(U) = E_{rp} - \frac{1}{2} A V_p$$

*[Equation # 27]*

where, $E(U)$ = expected utility value for investor

$Er_p$ = expected return on the portfolio

$A$= index of the investor risk aversion

$Vp$ = variance of the portfolio return

This form of utility function is consistent with the incorporated asset allocation approach (Sharpe, 1987). To determine the unique benefits of investing in commodity futures, a scale is developed to measure risk aversion level (A) for different kinds of investor i.e., 0(risk neutral), 1(aggressive), 2(moderately aggressive), 3(moderately conservative) and 4(conservative).

A risk neutral investor will judge a risky prospect solely by its expected return, regardless of the level of risk. On the contrary, a conservative investor penalizes risky asset more severely by opting either higher return for a given level of risk or lower risk for a given level of return. With the increase in value of (A) from 0 to 4, the associated level of risk aversion, there should be a larger proportion of investment in commodity futures. With the increase in the risk aversion level of the investor  the allocation to commodity futures should also increase to dampen the negative impact of portfolio volatility on expected utility (Anson, 1999). The proportion of investment in risk free asset and the risky asset is determined on the basis of different levels of investor's risk aversion (A). The optimal position in the risky asset ($y$) is proportional to risk premium and inversely proportional to variance and degree of risk aversion, as given by the following equation:

$$y = \frac{E_{rp} - r_f}{AV_p}$$

*[Equation # 28]*

where, $y$ = optimal position in risky portfolio, and

$r_f$ = risk free rate of return.

The above equation is derived by setting the utility equation (27) to maximization, meaning that by allocating y% of funds to risky portfolio and (1-y)% of funds to risk free portfolio, the investor would achieve the maximum utility at A level of risk aversion.

To assess the impact of inclusion of commodities, the study begins by considering an asset only investor in search of the optimal portfolio as taken by Bekkers et al. (2009). An asset only investor does not take liabilities into consideration and pursues the goal of wealth maximization with no other investment goal.

# CHAPTER-5

# ANALYSIS AND INTERPRETATIONS

The daily prices for asset classes from Indian Capital market, viz., Commodity futures (MCX COMDEX), Commodity Spot (MCXSCOMDEX), Equity (S&P CNX Nifty) and Bond (NSE G-Sec), are examined for the period June 2005 to December 2011 to investigate the diversifying properties of commodity futures. By adopting the research methodology as discussed in the previous section, the analysis is as follows:

## Test for Short Term Co-movement

The short term estimation of the relationship between the variables can be studied using the cross-correlation coefficients. For the asset to be included in a portfolio, it should have low or negative correlation with other assets existing in the portfolio. Therefore, we would identify the correlation of commodity futures with equity, bond and inflation.

From the table 3, it can be identified that returns on MCX COMDEX demonstrates a significant low correlation (0.36436) with the equity returns and a significant negative correlation (-0.35956) with bonds at 1% level of significance. There also exists a low correlation among returns of commodity futures and t-bills during the analyzed period. MCX Agri returns are the least correlated with equity. Thus, commodity futures have the potential to reduce risk in a portfolio of stocks and bonds and thereby diversifying the investor portfolio.

This evidence of low correlation of commodity future returns with other asset classes implies that the commodities are influenced by different economic fundamentals as compared to equity and bond.

**Table 3: Correlation Matrix for the Returns on different Asset Classes (2005-2011)**

| | WPI | CPI | S & P CNX Nifty | NSE G-Sec | MCX COMDEX | MCXS COMDEX | MCX Energy | MCX Metal | MCX Agri |
|---|---|---|---|---|---|---|---|---|---|
| **WPI** | 1 | | | | | | | | |
| **CPI** | .350** | 1 | | | | | | | |
| **S & P CNX Nifty** | -.385** | -0.15 | 1 | | | | | | |
| **NSE G-Sec** | 0.02 | 0.007 | -0.011 | 1 | | | | | |
| **MCX COMDEX** | -.294** | -0.19 | 0.364** | -0.360** | 1 | | | | |
| **MCXS COMDEX** | -.310** | -0.19 | 0.375** | -0.372** | 0.952** | 1 | | | |
| **MCX Energy** | -.250* | -0.17 | 0.318** | -0.416** | 0.871** | 0.870** | 1 | | |
| **MCX Metal** | -.257* | -0.17 | 0.368** | -0.218 | 0.833** | 0.769** | 0.518** | 1 | |
| **MCX Agri** | -0.12 | -0.03 | 0.062 | 0.068 | 0.283* | 0.254* | 0.03 | 0.229* | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Wholesale Price Index (WPI), as a measure of inflation, has a significant negative correlation with both the returns of equity and commodity futures. Although there is a marginal difference in the correlation of inflation with equity compared to commodities, this is due to the fact that the commodity futures index considered is a composite index. And a composite index would have certain commodities that tend to move in the positive direction with inflation (like agricultural commodities) and some commodities move in negative direction (like gold and silver), thus resulting in a correlation coefficient that may be at a higher end or an upper end. If we analyse the movement of commodity sub-indices with inflation, it can be seen that Agricultural commodities have the least negative correlation with inflation as compared to other two sub-indices. Therefore, the results show that if an investor is interested to invest in commodities for inflation hedging, then he might have to consider individual commodities or sub-indices. But overall, the commodity futures have a low negative correlation with inflation as compared to other asset classes.

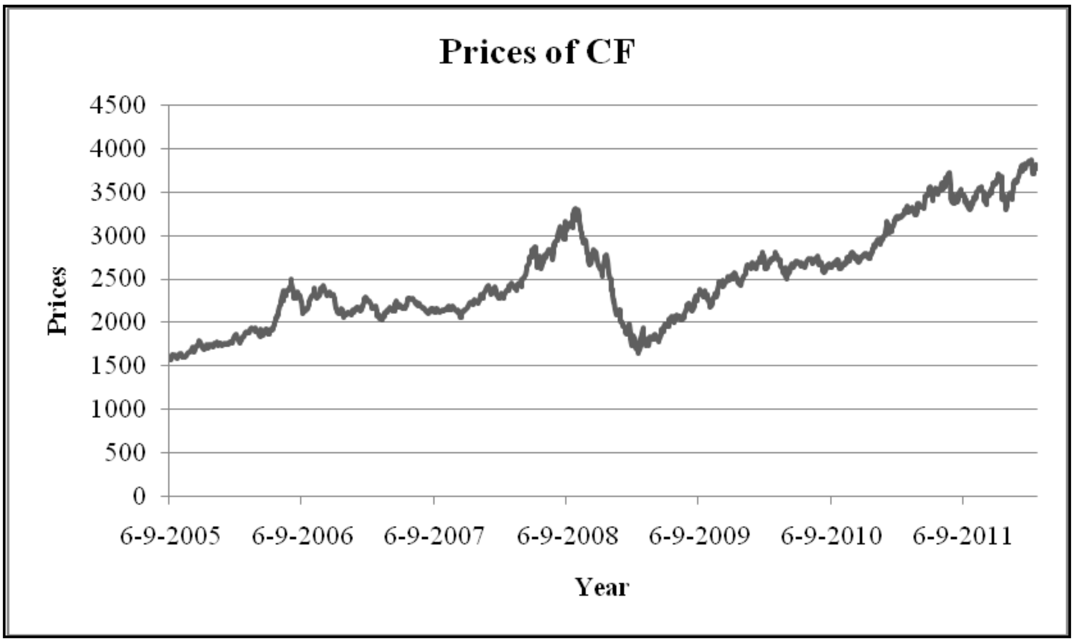
The correlation between commodity futures and commodity spot returns is very high, 0.952, they are nearly positively correlated to each other, so an investor is to decide among the two asset classes for investment. Although the benefits of investing in futures are comparatively large, like low transaction cost, ease of trading, etc, but then it depends on the type of investor whether he would invest in spot market or futures market. An investor who wants to take the delivery at the end of the contract may wish to invest in spot rather than futures and an investor who does not want to take delivery, is investing to earn the returns, does not have huge amount to invest and wants to square-off the position should invest in futures. Also the movement of spot returns with other asset classes is same as movement of futures with rest of the assets.

Commodity futures, thus have low or negative correlation with other asset classes, indicating that it can be treated as an investment asset in a traditional portfolio of equity and bond. The correlation results are used for studying the risk-return profile for portfolio construction. However, correlation is a short term connotation and does not represent a long term relationship among two variables. Therefore, the research tries to study the long term co-movement of commodity futures with equity and bond for their ability to reduce risk in a traditional portfolio in long run. The research also studies the co-movement of spot and futures market so as to determine any kind of deviations in the long term movement between the two price indices.

**Test of Stationarity**

To analyse the long term relation among the variables we use Johansen Cointegration Analysis. But, before running this analysis the data is checked for stationarity, the importance of which has been discussed in the previous section. Firstly, the data is visually checked for stationarity using the graphs. The presence of trend in a graph represents that the variable is non-stationary in nature. Figure 3 shows the line graph for Commodity Futures prices at level (CF) and at its first difference, [D(CF)] showing that on differencing, the price series becomes stationary which was otherwise non-stationary in nature.

**Figure 3: Line graphs of Commodity Future Prices at Level and at its First Difference.**



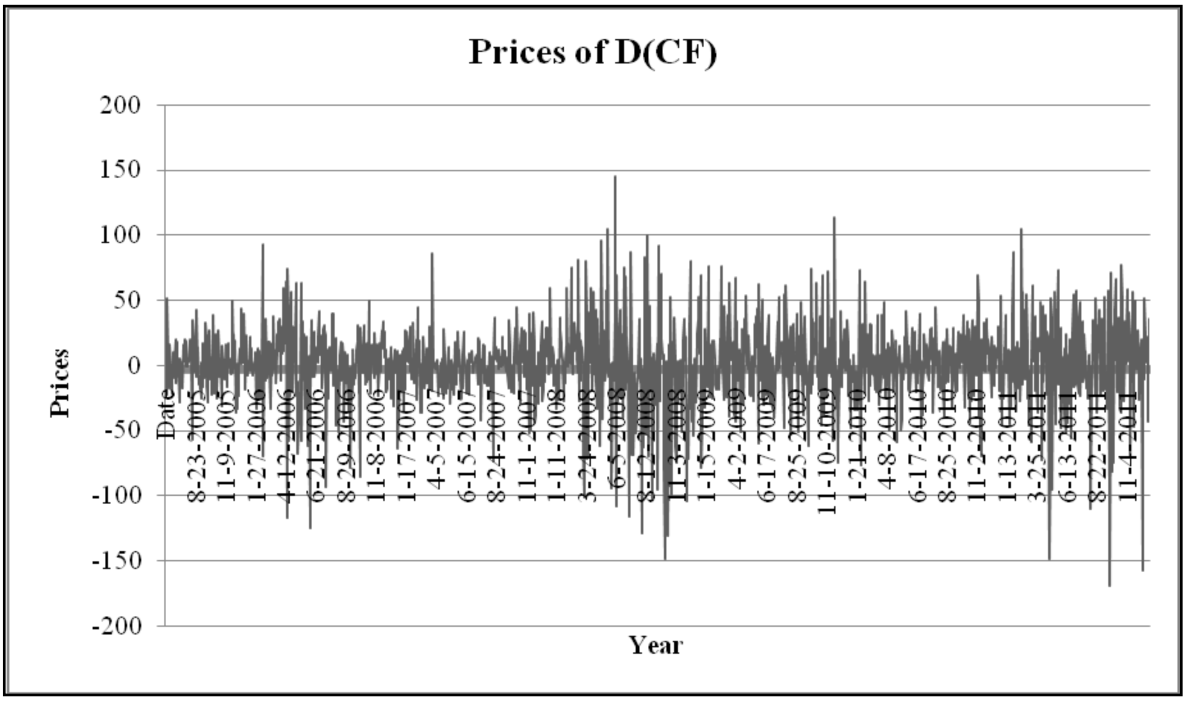
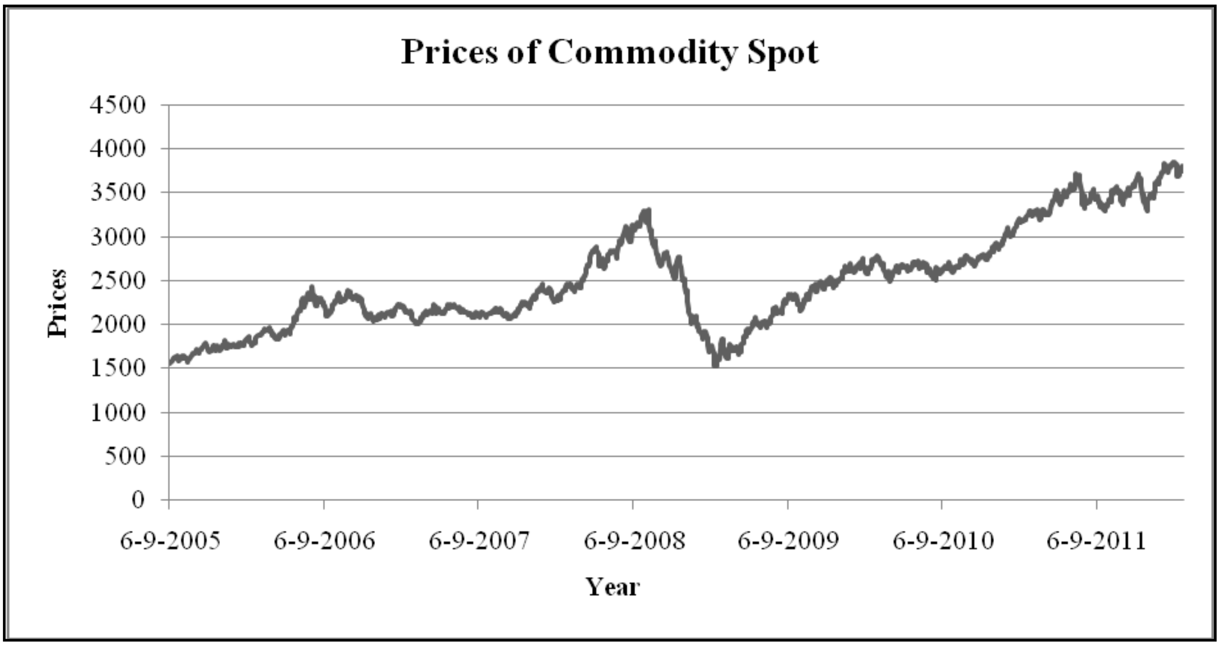



Figure 4 inflects the line graphs for Commodity Spot prices at levels and log of Commodity Spot [D(Spot)], giving the similar results. Similarly, the stationarity nature of all the asset indices is checked by drawing the line graphs.

**Figure 4: Line graphs of Commodity Spot Prices at Level and at its First Difference.**



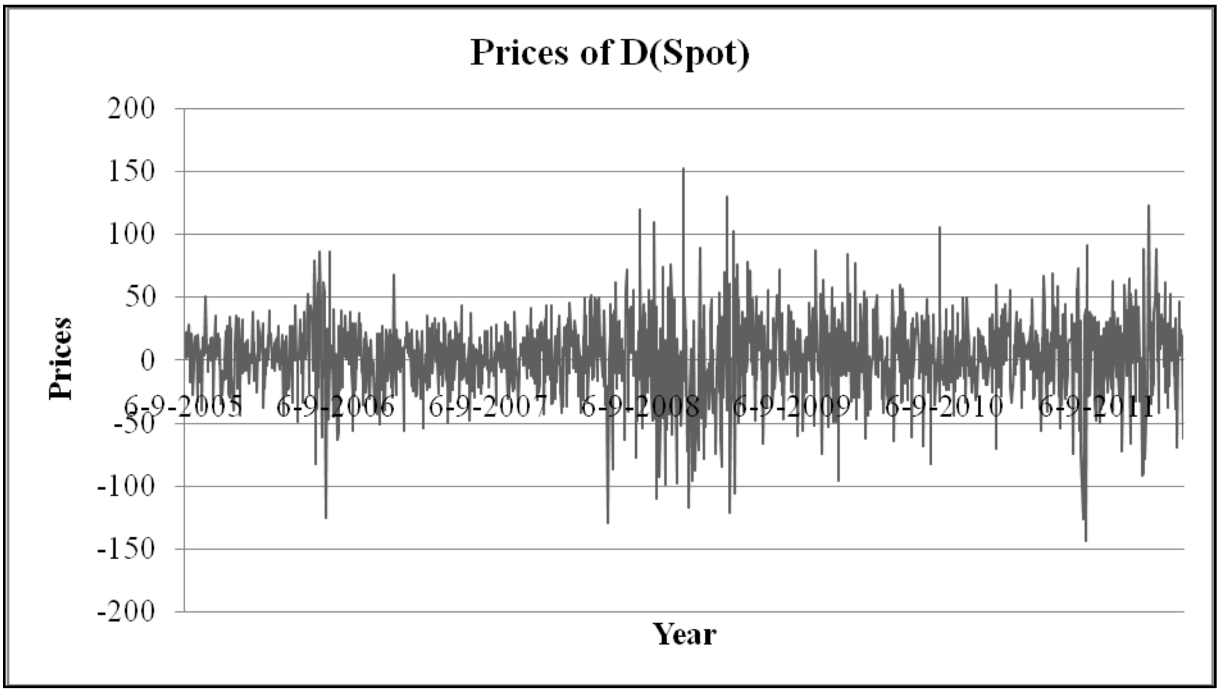



**Figure 5: Line graphs of Equity Prices at Levels and its First Difference.**

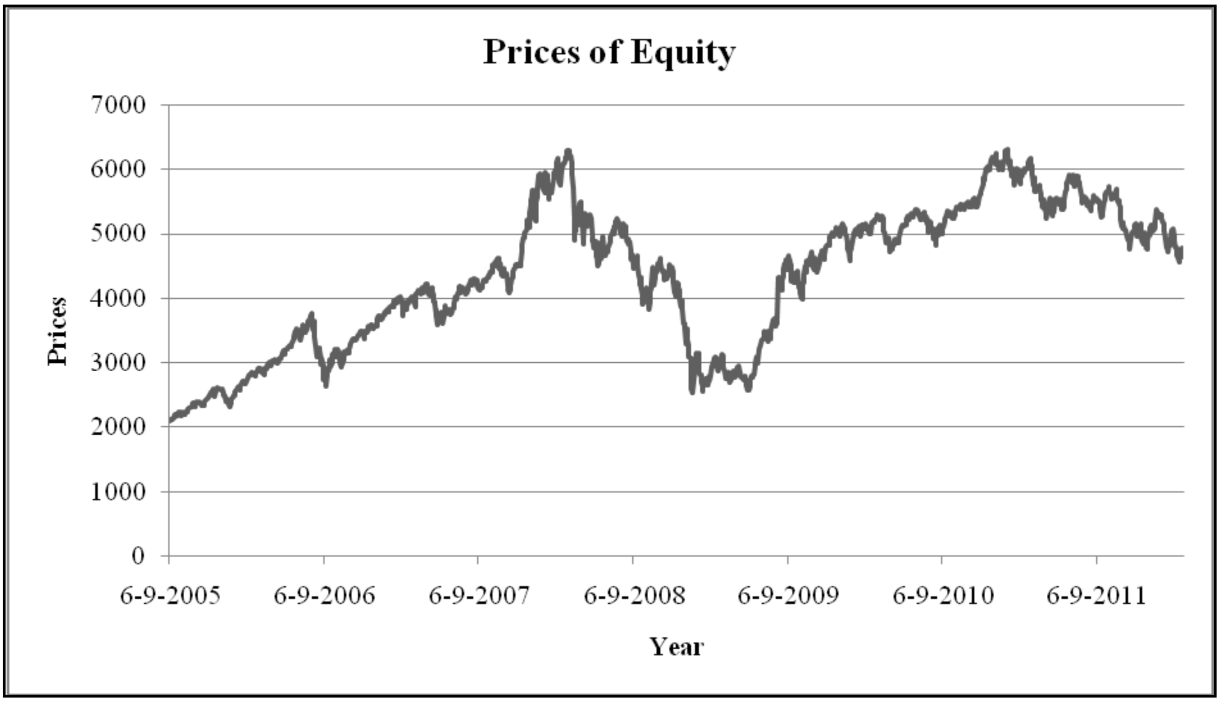



Figure 5 depicts the line graph for Equity prices, showing that the index is non-stationary at its levels but becomes stationary on first differencing. Figure 6 exhibits the line graph for bond prices at levels and at its first difference.

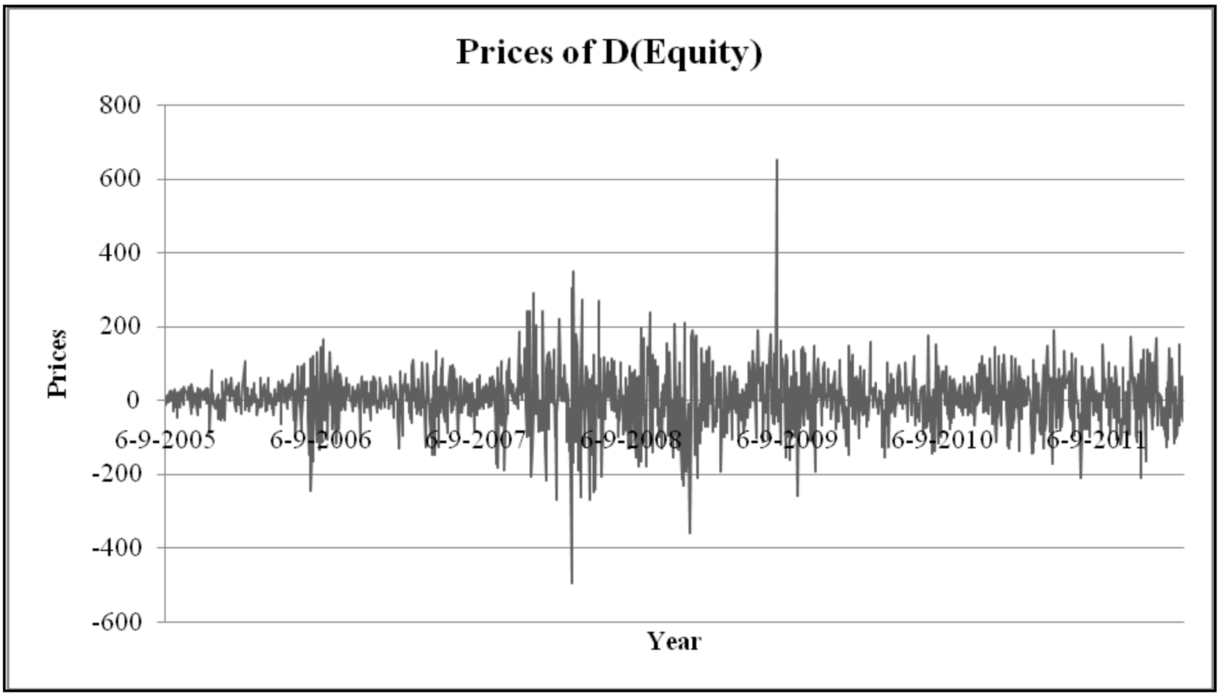
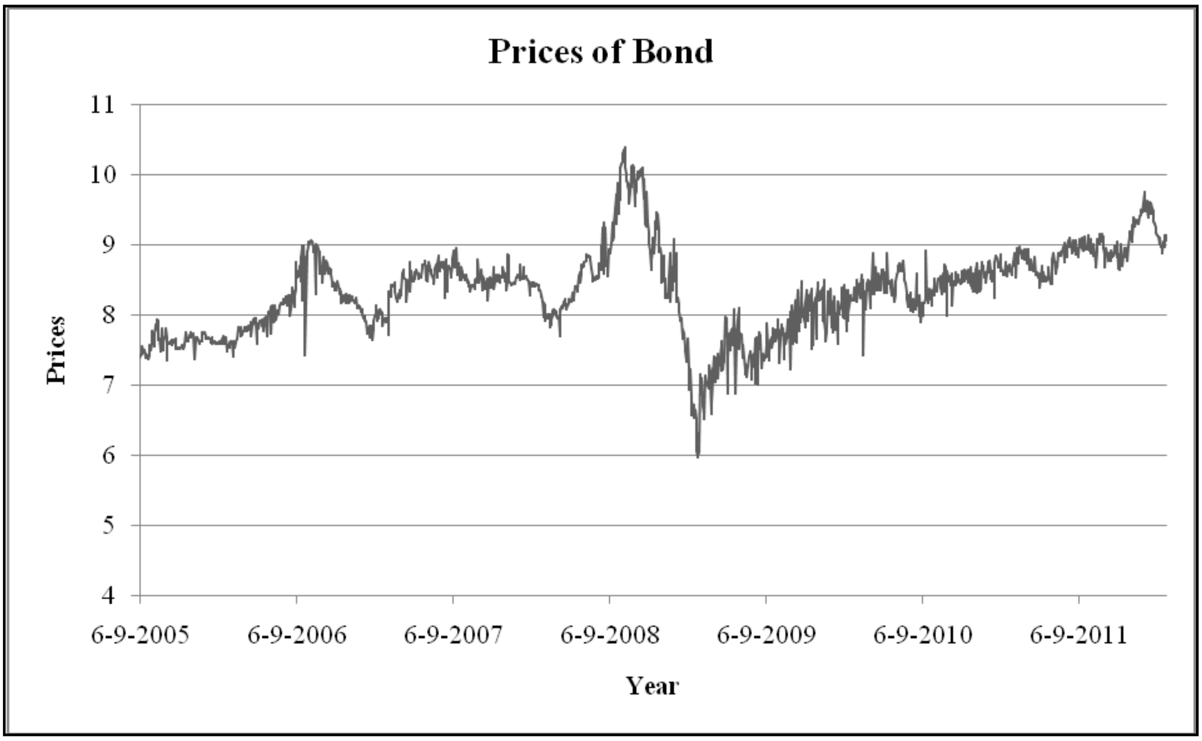
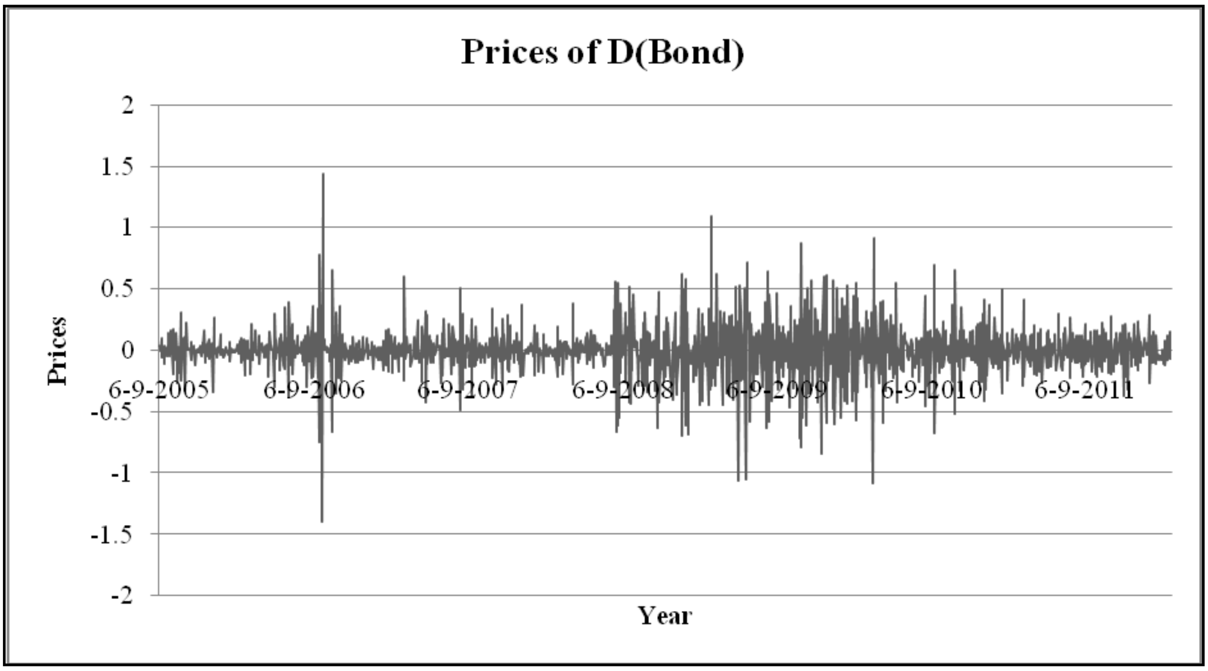


**Figure 6: Line graphs of Bond Prices at Levels and its First Difference.**



Therefore, by visual inspection of the line graph for all the asset classes, it can be inferred that all the four price indices are non-stationary at their levels and become stationary at their first differences.

Further, the study tests the stationarity by running Augmented Dickey Fuller test (ADF) on log of price indices. The optimal lag length is determined using minimum Akaike Information Criteria (AIC). The null hypothesis in case of ADF test is that the series under reference has a unit root, which implies that the series is not stationary in nature. A probability value of below 0.05 does not accept the null hypothesis at 5% level of significance and implies that the series under reference are stationary at 5% level of significance.

The null hypothesis that series at levels has unit root is accepted for all the four asset prices as the p-values is more than 0.05, depicting that the series are non-stationary at their levels (Tables 4.1, 4.3, 4.5 and 4.7). Similarly when we look at the test statistic value, the t-stat value is less than critical value at any reasonable level of statistical significance, henceforth we accept the null hypothesis. Thus, generating the same results as given by the probability values.

**Table 4.1: Unit Root results for CF**

| Null Hypothesis: CF has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -0.5490 | 0.8790 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

Next, we check for stationarity of all the four price series at their first differences. The null hypothesis that series has unit root at their first difference is rejected as p-values are less than 0.05 (Table 4.2, 4.4, 4.6 and 4.8). Similarly on testing the test statistic value, the test stat value is more than critical value at any reasonable level of statistical significance (1% and 5%), implying that the null hypothesis is not accepted and the variable does not have a unit-root, which confirms that all the series are stationary at their first differences, implying that all the indices are integrated of the order 1, I(1).

**Table 4.2: Unit Root results for D(CF)**

| Null Hypothesis: D(CF) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -37.226 | 0.0000 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8636 | |
| | 10% level | -2.5677 | |

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

**Table 4.3: Unit Root results for Spot**

| Null Hypothesis: SPOT has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -0.6026 | 0.8676 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

**Table 4.4: Unit Root results for D(Spot)**

| Null Hypothesis: D(SPOT) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -37.6898 | 0.0000 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

**Table 4.5: Unit Root results for Equity**

| Null Hypothesis: EQUITY has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -2.2098 | 0.2029 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

**Table 4.6: Unit Root results for D(Equity)**

| Null Hypothesis: D(EQUITY) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -36.9279 | 0.0000 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

**Table 4.7: Unit Root results for Bond**

| Null Hypothesis: BOND has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -2.7521 | 0.0656 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5677 | |

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

**Table 4.8: Unit Root results for D(Bond)**

| Null Hypothesis: D(BOND) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -33.1078 | 0.0000 |
| Test critical values: | 1% level | -3.4343 | |
| | 5% level | -2.8632 | |
| | 10% level | -2.5672 | |

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

**Table 5: Unit Root Tests for All Asset Classes**

| Variables | t-stat* | Prob. | Ho= non stationary |
|---|---|---|---|
| CF | -0.549 | 0.879 | Ho accepted |
| ΔCF | -37.226 | 0.0000 | Ho rejected |
| Spot | -0.6026 | 0.8676 | Ho accepted |
| ΔSpot | -37.69 | 0.0000 | Ho rejected |
| Equity | -2.2097 | 0.2029 | Ho accepted |
| ΔEquity | -36.928 | 0.0000 | Ho rejected |
| Bond | -2.7521 | 0.0656 | Ho accepted |
| ΔBond | -33.108 | 0.0000 | Ho rejected |

* significant at 1% level

The stationarity is verified at all the three conditions, i.e., no intercept - no trend, intercept but no trend, no intercept but trend. Since all the four price series are observed to be stationary in nature after the first difference, I(1), further econometric analysis can be performed on the prices of indices to determine the long term association of commodity futures with spot, equity and bond.

## Test of Long Term Co-movement & Model Formation

Since it is identified that all the four price series are integrated of the order 1, we can now run econometric analysis on the data to analyse the relationship of commodity futures with other asset classes. To run the cointegration analysis, we need to identify the optimum lag for all the systems differently among whom the long term relationship is to be identified. Optimum lag is identified using Vector Auto Regression Order selection criteria, wherein the VAR model is run for different criteria and the lag that gives the significant value for the system is considered to be the optimum lag length. The various criteria are LR: sequential modified LR test statistic, FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion and HQ: Hannan-Quinn information criterion. The AIC is considered to be the standardized criteria for selection of optimum lag length. The following tables 6.1, 6.2 and 6.3 respectively show the optimum lag for the three systems, CF and Spot, CF and Equity & CF and Bond.

**Table 6.1: Optimum Lag Length Selection: CF and Spot**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| **0** | -19809.9 | NA | 3.40e+08 | 25.3188 | 25.3256 | 25.3213 |
| **1** | -14776.1 | 10048.37 | 548582.4 | 18.8908 | 18.9114 | 18.8985 |
| **2** | -14653.7 | 243.9335 | 471576.7 | 18.7396 | 18.7738 | 18.7523 |
| **3** | -14615.2 | 76.6324 | 451243.6 | 18.6955 | 18.7434 | 18.7133 |
| **4** | -14595.3 | 39.6230 | 442152.4 | 18.6752 | 18.7367 | 18.6981 |
| **5** | -14578.8 | 32.776 | 435143.2 | 18.6592 | **18.7345*** | **18.6872*** |
| **6** | -14574.6 | 8.2731 | 435048.2 | 18.6589 | 18.7479 | 18.6920 |
| **7** | -14567.5 | 14.1756 | 433297.0 | 18.6549 | 18.7576 | 18.6931 |
| **8** | -14556.3 | **22.1117*** | **429341.1*** | **18.6458*** | 18.7621 | 18.6890 |

* indicates lag order selected by the criterion (each test at 5% level)

From the above table we can see that as per LR Criteria, FPE criteria and AIC criteria the number of lags required for the system is 8. Whereas, according to SC and HQ criteria the number of lags should be 5. Since out of five criteria, 3 suggest 8 as the lag length so we accept it to be the optimum lag length.

**Table 6.2: Optimum Lag Length Selection: CF and Equity**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| **0** | -24635.7 | NA | 1.62e+11 | 31.4859 | 31.4927 | 31.4884 |
| **1** | -16546.1 | 16148.10 | 5267667. | 21.1528 | **21.1734*** | 21.1605 |
| **2** | -16535.1 | **22.02656*** | **5220430.*** | **21.1438*** | 21.1781 | **21.1566*** |
| **3** | -16534.5 | 1.1918 | 5243172. | 21.1482 | 21.1961 | 21.1660 |
| **4** | -16532 | 4.8497 | 5253644. | 21.1502 | 21.2118 | 21.1731 |
| **5** | -16531.2 | 1.6437 | 5274987. | 21.1542 | 21.2295 | 21.1822 |
| **6** | -16526.4 | 9.4707 | 5269767. | 21.1533 | 21.2422 | 21.1863 |
| **7** | -16523.4 | 5.8948 | 5276670. | 21.1546 | 21.2572 | 21.1927 |
| **8** | -16523.1 | 0.6233 | 5301580. | 21.1593 | 21.2756 | 21.2025 |

* indicates lag order selected by the criterion (each test at 5% level)

From the table 6.2, we can see that as per LR Criteria, FPE criteria, AIC criteria and HQ criteria the number of lags required for the system is 2. Whereas, according to SC criteria the number of lags should be 1. Since out of five criteria, 4 suggest 2 as the lag length so we accept it to be the optimum lag length.

**Table 6.3: Optimum Lag Length Selection: CF and Bond**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| **0** | -13076.2 | NA | 62170.75 | 16.7134 | 16.7202 | 16.7159 |
| **1** | -7231.88 | 11666.31 | 35.6563 | 9.2497 | 9.2702 | 9.2573 |
| **2** | -7053.84 | 354.9372 | 28.5459 | 9.0273 | 9.0615 | 9.0399 |
| **3** | -7009.43 | 88.4177 | 27.1092 | 8.9757 | **9.0235*** | 8.9934 |
| **4** | -6996.04 | **26.6263*** | **26.7858*** | **8.9637*** | 9.0252 | **8.9865*** |
| **5** | -6992.17 | 7.6876 | 26.7903 | 8.9638 | 9.0391 | 8.9918 |
| **6** | -6989.35 | 5.5846 | 26.8309 | 8.9654 | 9.0543 | 8.9984 |
| **7** | -6988.18 | 2.3312 | 26.9278 | 8.9689 | 9.0716 | 9.0071 |
| **8** | -6985.87 | 4.5627 | 26.9862 | 8.9711 | 9.0874 | 9.0143 |

* indicates lag order selected by the criterion (each test at 5% level)

From the above table we can see that as per LR Criteria, FPE criteria, AIC criteria and HQ criteria the number of lags required for the system is 4. Whereas, according to SC criteria the number of lags should be 3. Since out of five criteria, four suggest 3 as the lag length so we accept it to be the optimum lag length. The results are compiled in the following table.

**Table 6.4: Optimum Lag length for all the systems**

| Model | Optimum Lag length |
|---|---|
| CF-Spot | 8 |
| CF-Equity | 2 |
| CF-Bond | 4 |

Once the optimum lag lengths are determined for all the three systems, we can further apply Johansen and Juselius (1990) multivariate co-integration tests to determine the number of cointegrating equations, r among the variables. The results are shown in following tables.

Table 7.1, 8.1 and 9.1 shows the results of Johansen Cointegration analysis run among the variables. The results are further compiled in Tables 7.2, 8.2 and 9.2. Johansen Cointegration results can be studied by two methods, either on the basis of Trace value or Max Eigen value. In both the cases, there are two null hypothesis, first $H_0$ is r=0, which means that there is no cointegrating equation between the variables and second $H_0$ r<=1 means that there is at least one cointegrating equation among the variables. Panel 1 in table 7.1, shows the result of trace test and it can be identified that p-value 0.0006 is less than 0.05, so we reject the null hypothesis that r=0. We then check for second null hypothesis that r<=1, at this condition p-value is 0.5406 which is more than 0.05, so we accept the null hypothesis. Similar results are achieved by observing Max-eigen test in panel 2, that there is one cointegrating equation, as first null hypothesis of r=0 is rejected whereas second null hypothesis of r<=1 is accepted (p-value 0.5406>0.05). As a result, both the tests confirm that there is a long term association among commodity futures and commodity spot prices, which validates the existing economic theory that spot is underlying asset for commodity futures, therefore spot prices drives the future prices.

**Table 7.1: Results of Johansen Co-integration between Commodity Futures & Spot**

| **Unrestricted Cointegration Rank Test (Trace)** | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 8 | | | | |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None *** | 0.01690 | 27.0330 | 15.4947 | 0.0006 |
| **At most 1** | 0.00023 | 0.37445 | 3.84146 | 0.5406 |
| Trace test indicates 1 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None *** | 0.01690 | 26.6585 | 14.2646 | 0.0004 |
| **At most 1** | 0.00024 | 0.37445 | 3.84146 | 0.5406 |
| Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Long Run Johansen Cointegration Equation | | | |
|---|---|---|---|
| 1 Cointegrating Equation(s): | | Log likelihood | -14542.53 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | | | |
| **CF** | **SPOT** | | |
| 1.000000 | -0.9932<br>(0.0084) | | |
| Adjustment coefficients (standard error in parentheses) | | | |
| D(CF) | -0.06635<br>(0.0308) | | |
| D(SPOT) | 0.07047<br>(0.0293) | | |

Panel 3 of the above table shows the long run cointegration equation of Johansen, where Spot is the independent variable and Commodity future prices are dependent variable. It presents the estimates which have been normalised so that the coefficient on commodity futures is unity. The relation is further extended and studied running Vector Error Correction Model.

**Table 7.2: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Spot**

| Lag: 8 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 27.0330 | 15.4947 | 0.0006 | 26.6586 | 14.2646 | 0.0004 |
| **r≤1** | 0.37445 | 3.84146 | 0.5406 | 0.37445 | 3.84146 | 0.5406 |

**Table 8.1: Results of Johansen Cointegration between Commodity Futures & Equity**

| Unrestricted Cointegration Rank Test (Trace) | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 4 | | | | |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.00507 | 13.7389 | 15.4947 | 0.0904 |
| **At most 1*** | 0.00368 | 5.77449 | 3.8415 | 0.0163 |
| Trace test indicates no cointegration at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.00507 | 7.9645 | 14.2646 | 0.3823 |
| **At most 1*** | 0.00368 | 5.7745 | 3.84147 | 0.0163 |
| Max-eigenvalue test indicates no cointegration at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Long Run Johansen Cointegration Equation | |
|---|---|
| 1 Cointegrating Equation(s): | Log likelihood -16563.05 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | |
| **CF** | **EQUITY** |
| 1.000000 | -1.17834 |
| | (0.3065) |
| Adjustment coefficients (standard error in parentheses) | |
| D(CF) | -0.00168 |
| | (0.00083) |
| D(EQUITY) | 0.00328 |
| | (0.00204) |

**Table 8.2: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Equity**

| Lag: 2 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 13.7389 | 15.4947 | 0.0904 | 7.9645 | 14.2646 | 0.3823 |
| **r≤1** | 5.77449 | 3.8415 | 0.0163 | 5.7745 | 3.84147 | 0.0163 |

In table 8.1, Panel 1 shows the result of trace test that indicates that there is no cointegration at level as p-value of 0.0904 is more than 0.05 and critical value (15.495) is more than the trace statistic(13.739), therefore we accept the first null hypothesis that there is no cointegration equation among the variables and thereby we do not need to check the second hypothesis because both the null hypothesis cannot be accepted simultaneously. On the similar lines, Max-eigen value also indicates no long term association among the variables by accepting the null hypothesis that there is zero cointegrating equation, with p-value 0.3823 more than 0.05 and critical value (14.264) is more than the max eigen statistics (7.964). Therefore, both the tests validate that there is no cointegration among equity and commodity futures implying that two time series drift away in long run and do not return to their equilibrium level. Table 8.1 also shows the long term cointegartion equation among commodity future and equity. The negative coefficient of independent variable, Equity is -1.178339 which supports the negative co-movement among the two variables.

**Table 9.1: Results of Johansen Cointegration between Commodity Futures & Bond**

| **Unrestricted Cointegration Rank Test (Trace)** | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 4 | | | | |
| **Hypothesized No. of CE(s)** | **Eigen Value** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None*** | 0.01332 | 21.9297 | 15.4947 | 0.0047 |
| **At most 1** | 0.00057 | 0.8971 | 3.8415 | 0.3436 |
| Trace test indicates 1 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None*** | 0.01332 | 21.0327 | 14.2646 | 0.0037 |
| **At most 1** | 0.00057 | 0.8971 | 3.8415 | 0.3436 |
| Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Long Run Johansen Cointegration Equation | |
|---|---|
| 1 Cointegrating Equation(s): | Log likelihood -7003.278 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | |
| **CF** | **BOND** |
| 1.000000 | -1228.715<br>(187.851) |
| Adjustment coefficients (standard error in parentheses) | |
| D(CF) | 0.00359<br>(0.00149) |
| D(BOND) | 0.00000<br>(8.2E-06) |

**Table 9.2: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for CF and Bond**

| Lag: 4 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **Λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 21.9297 | 15.4947 | 0.0047 | 21.0327 | 14.2646 | 0.0037 |
| **r≤1** | 0.8971 | 3.8415 | 0.3436 | 0.8971 | 3.8415 | 0.3436 |

From the first panel of table 9.1, trace value indicates that there is a long term relationship at level as p-value of 0.47% is less than 5% and critical value (15.495) is less than the trace statistic (21.9297), therefore we accept the null hypothesis that there is one cointegration equation among the variables. On the similar lines, Max-eigen value also indicates a long term association among the variables by rejecting the null hypothesis(r=0) that there is zero cointegrating equation, with p-value 0.37% is less than 5% and critical value(14.264) is less than the max eigen statistics (21.033). Therefore, both the tests substantiate that there is one cointegration equation among commodity futures and bond.

**Model Formation**

Since the above results show that there is one cointegrating equation for CF-Spot and CF-Bond, but no long term association or no cointegration among CF-Equity. If the variables are cointegrated, means in long run they return to their equilibrium. Vector Error Correction Model helps in identifying the short and long run effects of explanatory variable and if the variables are non cointegrating, running VECM will not yield the results as there is no long term association. Therefore we run VECM among CF-Spot and CF-Bond and use VAR for CF-Equity to identify the cause and effect relationship. The statistical significance of the coefficients of the models derived through VAR/VECM is examined through Ordinary Least Square Method. The null hypothesis taken for OLS is that the coefficients of the independent variables are non-significant to explain the dependent variable. The results are shown in following table:

**Table 10: Vector Error Correction Estimates for CF-Spot**

| **Cointegrating Eq:** | **CointEq1** | |
|---|---|---|
| **CF(-1)** | 1.0000 | |
| **SPOT(-1)** | -0.9932 | |
| | (0.0084) | |
| | [-118.302] | |
| **C** | -46.4501 | |
| | | |
| **Error Correction:** | **D(CF)** | **D(SPOT)** |
| **CointEq1** | -0.0663 | 0.0704 |
| *t-statistic* | [-2.1510] | [ 2.4016] |
| *Prob.* | **0.03160** | **0.01640** |
| **D(CF(-1))** | -0.12138 | 0.53264 |
| *t-statistic* | [-2.9235] | [ 13.4782] |
| *Prob.* | **0.0035** | **0.0000** |
| **D(CF(-2))** | -0.3025 | 0.2250 |

| | | |
|---|---|---|
| *t-statistic* | [-6.6377] | [ 5.1869] |
| *Prob.* | **0.0000** | **0.0000** |
| **D(CF(-3))** | -0.22618 | 0.15789 |
| *t-statistic* | [-4.8232] | [ 3.5374] |
| *Prob.* | **0.0000** | **0.0004** |
| **D(CF(-4))** | -0.17137 | 0.152395 |
| *t-statistic* | [-3.64394] | [ 3.40443] |
| *Prob.* | **0.000300** | **0.000700** |
| **D(CF(-5))** | -0.134827 | 0.115010 |
| *t-statistic* | [-2.93489] | [ 2.63025] |
| *Prob.* | **0.003400** | **0.008600** |
| **D(CF(-6))** | -0.116486 | 0.098491 |
| *t-statistic* | [-2.66308] | [ 2.36569] |
| *Prob.* | **0.007800** | **0.018100** |
| **D(CF(-7))** | -0.060975 | 0.078162 |
| *t-statistic* | [-1.53041] | [ 2.06112] |
| *Prob.* | 0.126000 | **0.039400** |
| **D(CF(-8))** | -0.064453 | 0.029449 |
| *t-statistic* | [-1.88643] | [ 0.90555] |
| *Prob.* | 0.059300 | 0.365200 |
| **D(SPOT(-1))** | 0.325988 | -0.250726 |
| *t-statistic* | [ 7.66740] | [-6.19576] |
| *Prob.* | **0.000000** | **0.000000** |
| **D(SPOT(-2))** | 0.266794 | -0.216339 |
| *t-statistic* | [ 5.95224] | [-5.07095] |
| *Prob.* | **0.000000** | **0.000000** |
| **D(SPOT(-3))** | 0.227872 | -0.180822 |
| *t-statistic* | [ 4.95972] | [-4.13490] |
| *Prob.* | **0.000000** | **0.000000** |
| **D(SPOT(-4))** | 0.216333 | -0.110311 |
| *t-statistic* | [ 4.67656] | [-2.50537] |
| *Prob.* | **0.000000** | **0.012300** |
| **D(SPOT(-5))** | 0.093924 | -0.120824 |
| *t-statistic* | [ 2.06655] | [-2.79301] |
| *Prob.* | **0.038900** | **0.005300** |
| **D(SPOT(-6))** | 0.116081 | -0.100969 |
| *t-statistic* | [ 2.68531] | [-2.45398] |
| *Prob.* | **0.007300** | **0.014200** |
| **D(SPOT(-7))** | 0.074456 | -0.113336 |
| *t-statistic* | [ 1.88963] | [-3.02200] |
| *Prob.* | 0.058900 | **0.002500** |
| **D(SPOT(-8))** | 0.056358 | -0.009080 |

| | | |
|---|---|---|
| *t-statistic* | [ 1.78729] | [-0.30253] |
| *Prob.* | 0.074000 | 0.762300 |
| **C** | 1.149519 | 0.955582 |
| *t-statistic* | [ 1.54107] | [ 1.34594] |
| *Prob.* | 0.123400 | 0.178400 |
| **R-squared** | 0.096476 | 0.212425 |
| **Adj. R-squared** | 0.086540 | 0.203765 |
| **Sum sq. Resids** | 1325477. | 1200807. |
| **S.E. equation** | 29.28070 | 27.86967 |
| **F-statistic** | 9.710431 | 24.52871 |
| **Log likelihood** | -7491.684000 | 7414.439000 |
| **Akaike AIC** | 9.603176 | 9.504398 |
| **Schwarz SC** | 9.664807 | 9.566028 |
| **Mean dependent** | 1.383478 | 1.358523 |
| **S.D. dependent** | 30.63633 | 31.23282 |

Since there is one cointegrating equation among CF and Spot, as a result we run VECM and the model takes the first differential of the variables as the dependent variables, i.e., D(CF) and D(SPOT) at lag 8. VECM model defines the cointegrating equation between CF-Spot. The values of all the coefficients of independent variables, their respective t-statistic and p-values are determined.

**Equation 1:** D(CF) = C(1)*( CF(-1) - 0.993164158546*SPOT(-1) -46.4500960782 ) + C(2)*D(CF(-1)) + C(3)*D(CF(-2)) + C(4)*D(CF(-3)) + C(5)*D(CF(-4)) + C(6)*D(CF(-5)) + C(7)*D(CF(-6)) + C(8)*D(CF(-7)) + C(9)*D(CF(-8)) + C(10)*D(SPOT(-1)) + C(11)*D(SPOT(-2)) + C(12) *D(SPOT(-3)) + C(13)*D(SPOT(-4)) + C(14)*D(SPOT(-5)) + C(15) *D(SPOT(-6)) + C(16)*D(SPOT(-7)) + C(17)*D(SPOT(-8)) + C(18)

**Equation 2:** D(SPOT) = C(19)*( CF(-1) - 0.993164158546*SPOT(-1) -46.4500960782 ) + C(20)*D(CF(-1)) + C(21)*D(CF(-2)) + C(22)*D(CF(-3)) + C(23)*D(CF(-4)) + C(24)*D(CF(-5)) + C(25)*D(CF(-6)) + C(26)*D(CF(-7)) + C(27)*D(CF(-8)) + C(28)*D(SPOT(-1)) + C(29)*D(SPOT(-2)) + C(30)*D(SPOT(-3)) + C(31)*D(SPOT(-4)) + C(32)*D(SPOT(-5)) + C(33)*D(SPOT(-6)) + C(34)*D(SPOT(-7)) + C(35)*D(SPOT(-8)) + C(36)

We get two models, one has commodity futures (CF) as dependent variable and another has Spot as a dependent variable. C(1) is the coefficient of co-integrating equation and C(2) to C(9) are the coefficients of lagged commodity futures prices for lags 1-8 and C(10) to C(17) are the coefficients of lagged spot prices for lags 1-8. For equation 1, where CF is the dependent variables, the coefficients of all the independent variables are verified for their significant contribution in influencing the dependent variable. The null hypothesis to validate the significance level is that the coefficients of independent variable are not significant to impact the dependent variable. From the table 10, it can be examined that CF is explained by its own lagged values and also by the lag values of Spot as the coefficients of D(Spot-1), D(Spot-2), D(Spot-3), D(Spot-4), D(Spot-5) and D(Spot-6) are significant (as p-values are less than 0.05), the rest of the coefficients are insignificant in nature.  In case of second equation where Spot is the dependent variable, C(19) is the coefficient of co-integrating equation, C(20) to C(27) are the coefficients of lagged commodity future prices for lags 1-8 and C(28) to C(35) are the coefficients of lagged commodity spot prices for lags 1-8. The coefficients of CF till lag 7 are significant to explain Spot and it is also influence by its own lagged variables. Thus, it can be inferred that the two price indices move together in the long run as verified by the co-integration results.

**Table 11: Vector Autoregression Estimates among CF and Equity**

| | **D(CF)** | **D(EQUITY)** |
|---|---|---|
| **D(CF(-1))** | 0.059196 | 0.200758 |
| *t-statistic* | [ 2.31372] | [ 3.17852] |
| *Prob.* | **0.020700** | **0.001500** |
| **D(CF(-2))** | -0.013107 | 0.042351 |
| *t-statistic* | [-0.51070] | [ 0.66842] |
| *Prob.* | 0.609600 | 0.503900 |
| **D(EQUITY(-1))** | 0.007948 | 0.056309 |
| *t-statistic* | [ 0.76720] | [ 2.20167] |
| *Prob.* | 0.443000 | **0.027800** |
| **D(EQUITY(-2))** | 0.002046 | -0.009933 |
| *t-statistic* | [ 0.19812] | [-0.38956] |

| | | |
|---|---|---|
| *Prob.* | 0.843000 | 0.696900 |
| **C** | 1.321037 | 1.192028 |
| *t-statistic* | [ 1.70762] | [ 0.62416] |
| *Prob.* | 0.087800 | 0.532600 |
| **R-squared** | 0.004325 | 0.011736 |
| **Adj. R-squared** | 0.001780 | 0.009210 |
| **Sum sq. Resids** | 1464314. | 8924151. |
| **S.E. equation** | 30.58862 | 75.51379 |
| **F-statistic** | 1.699407 | 4.646380 |
| **Log likelihood** | -7595.616000 | -9014.405000 |
| **Akaike AIC** | 9.682313 | 11.48969 |
| **Schwarz SC** | 9.699379 | 11.50675 |
| **Mean dependent** | 1.401465 | 1.606083 |
| **S.D. dependent** | 30.61588 | 75.86397 |
| **Determinant resid covariance (dof adj.)** | | 5210353. |
| **Determinant resid covariance** | | 5177219. |
| **Log likelihood** | | -16591.39 |
| **Akaike information criterion** | | 21.14827 |
| **Schwarz criterion** | | 21.18240 |

The above table has generated two equations with CF and Equity respectively as the dependent variables. The values of all the coefficients of independent variables are determined and also their respective t-statistic. To identify whether the coefficients have significant impact on the dependent variable, we need to identify their p-values, which are determined by running Ordinary Least Square Method.

**Equation 3:** DCF = C(1)*DCF(-1) + C(2)*DCF(-2) + C(3)*DEQUITY(-1) + C(4) *DEQUITY(-2) + C(5)

**Equation 4:** DEQUITY = C(6)*DCF(-1) + C(7)*DCF(-2) + C(8)*DEQUITY(-1) + C(9)*DEQUITY(-2) + C(10)

Equation 3 has first difference of commodity future price (DCF) as the dependent variable, where C(1) and C(2) are the coefficients of lagged commodity future prices for lag 1-2 and C(3) and C(4) are the coefficients of lagged equity prices for lag 1-2. Equation 4 has first difference of equity prices D(Equity) as the dependent variable and C(6) and C(7) are the coefficients of lagged commodity future prices for lag 1-2 and C(8) and C(9) are the coefficients of lagged equity prices for lag 1-2. From Table 11, it can be identified that only C(1), C(6) and C(8) are significant as the p-values are less than 5%. It implies that first lag of commodity futures is significant to explain the present value of commodities and for equation 4, equity price is dependent on only the first lag of commodity futures and equity, is independent of the second lag values of both commodity and equity. These results confine to the results given by cointegration analysis.

**Table 12: Vector Error Correction Estimates for CF-Bond**

| **Cointegrating Eq:** | **CointEq1** | |
|---|---|---|
| **CF(-1)** | 1.000000 | |
| **BOND(-1)** | -1228.715 | |
| | (187.851) | |
| | [-6.54091] | |
| **C** | 7718.903 | |
| | | |
| **Error Correction:** | **D(CF)** | **D(BOND)** |
| **CointEq1** | 0.003587 | 3.21E-05 |
| *t-statistic* | [ 2.41510] | [ 3.92271] |
| *Prob.* | **0.015800** | **0.000100** |
| **D(CF(-1))** | 0.055929 | 0.000231 |
| *t-statistic* | [ 2.19988] | [ 1.65160] |
| *Prob.* | **0.027900** | 0.098700 |
| **D(CF(-2))** | -0.021569 | 0.000215 |
| *t-statistic* | [-0.84659] | [ 1.53048] |
| *Prob.* | 0.397300 | 0.126000 |
| **D(CF(-3))** | 0.008693 | 0.000321 |
| *t-statistic* | [ 0.34102] | [ 2.28420] |
| *Prob.* | 0.733100 | **0.022400** |
| **D(CF(-4))** | 0.010341 | 0.000109 |
| *t-statistic* | [ 0.40611] | [ 0.77926] |
| *Prob.* | 0.684700 | 0.435900 |
| **D(BOND(-1))** | 9.884657 | -0.604888 |
| *t-statistic* | [ 2.07537] | [-23.0631] |
| *Prob.* | **0.038000** | **0.000000** |
| **D(BOND(-2))** | 7.268019 | -0.323102 |
| *t-statistic* | [ 1.33572] | [-10.7832] |
| *Prob.* | 0.181700 | **0.000000** |
| **D(BOND(-3))** | 5.892989 | -0.150249 |

| | | |
|---|---|---|
| *t-statistic* | [ 1.09367] | [-5.06376] |
| *Prob.* | 0.274200 | **0.000000** |
| **D(BOND(-4))** | 8.081271 | -0.048460 |
| *t-statistic* | [ 1.76784] | [-1.92511] |
| *Prob.* | 0.077200 | 0.054300 |
| **C** | 1.276769 | 0.000933 |
| *t-statistic* | [ 1.64993] | [ 0.21893] |
| *Prob.* | 0.099100 | 0.826700 |
| **R-squared** | 0.011197 | 0.298082 |
| **Adj. R-squared** | 0.005485 | 0.294028 |
| **Sum sq. Resids** | 1451184. | 44.00544 |
| **S.E. equation** | 30.51951 | 0.168062 |
| **F-statistic** | 1.960234 | 73.51485 |
| **Log likelihood** | -7579.878000 | 576.5269 |
| **Akaike AIC** | 9.680967 | -0.722611 |
| **Schwarz SC** | 9.715135 | -0.688443 |
| **Mean dependent** | 1.384630 | 0.000973 |
| **S.D. dependent** | 30.60355 | 0.200021 |

Since there is one cointegrating equation among CF and Bond therefore we run VECM and the model takes the first differential of the variables as the dependent variables, i.e., D(CF) and D(Bond) at lag 4. The values of all the coefficients of independent variables are determined and also their respective t-statistic. To identify whether the coefficients have significant impact on the dependent variable, we need to identify their p-values, which would be determined by running Ordinary Least Square Method.

**Equation 5:** D(CF) = C(1)*( CF(-1) - 1228.71540224*BOND(-1) +7718.90279686 ) + C(2)*D(CF(-1)) + C(3)*D(CF(-2)) + C(4)*D(CF(-3)) + C(5)*D(CF(-4)) + C(6)*D(BOND(-1)) + C(7)*D(BOND(-2)) + C(8) *D(BOND(-3)) + C(9)*D(BOND(-4)) + C(10)

**Equation 6:** D(BOND) = C(11)*( CF(-1) - 1228.71540224*BOND(-1) +7718.90279686 ) + C(12)*D(CF(-1)) + C(13)*D(CF(-2)) + C(14)*D(CF(-3)) + C(15)*D(CF(-4)) + C(16)*D(BOND(-1)) + C(17)*D(BOND(-2)) + C(18)*D(BOND(-3)) + C(19)*D(BOND(-4)) + C(20)

For equation 5, where, CF is the dependent variable, C(1) is the coefficient of co-integrating equation, C(2) to C(5) are the coefficients of lagged values of commodity future prices for lags 1-4 and C(6) to C(9) are the coefficients of lagged values of bond prices for lags 1-4. From table 12, the coefficients of D(CF(-1)), D(Bond(-1)) has a significant influence on CF while other coefficients are non-significant in nature.

For equation 6, where Bond is the dependent variable, C(11) is the coefficient of co-integrating equation, C(12) to C(15) are the coefficients of lagged values of commodity future prices for lags 1-4 and C(16) to C(19) are the coefficients of lagged values of bond prices for lags 1-4.D(CF(-3)), D(Bond(-1)), D(Bond(-2)), D(Bond(-3)) are significant whereas the rest of the independent variables in the equation are insignificant in nature.

## Test to check the Statistical Validity of Residuals of the Models

### ARCH Test:

This test is done to check the Autoregressive Conditional Heteroskedasticity (ARCH) in the residuals. Heteroskedasticity means the variance of the residuals in (t) period are dependent on the variance of the residuals of the (t-1) period. ARCH is most likely to occur in the daily data time series (Balarezo, 2010). Therefore, cointegration analysis was tested for monthly data also, in an attempt to remove ARCH from the daily data series. However, the heteroskedasticity of the residuals was not eliminated – although decreased slightly for some series. The cointegration estimation results obtained from monthly data was usually the same as the results obtained from daily data. Therefore we cannot essentially overcome ARCH in the time series data. Hendry & Juselius (2000) note that if a set of series is cointegrated at levels, they will also be cointegrated in log levels. That is even if the variable is transformed, cointegration would remain either for daily data or monthly data, the results would remain same.

**Lagrange Multiplier (LM) Test for Serial Correlation:**

To check the serial correlation among the residuals, Breusch-Godfrey Serial Correlation LM Test is used. The null hypothesis taken for the test is that there is no serial correlation among the residuals. So for the models to hold true, the test should accept the null hypothesis for the given data.

**Table 13.1: LM Test Results among CF and Spot**

| | | | |
|---|---|---|---|
| F-statistic | 0.7383 | Prob. F(2,1544) | 0.4781 |
| Obs*R-squared | 1.4944 | Prob. Chi-Square(2) | 0.4737 |

**Table 13.2: LM Test Results among CF and Equity**

| | | | |
|---|---|---|---|
| F-statistic | 0.1562 | Prob. F(2,1564) | 0.8554 |
| Obs*R-squared | 0.3137 | Prob. Chi-Square(2) | 0.8548 |

**Table 13.3: LM Test Results among CF and Bond**

| | | | |
|---|---|---|---|
| F-statistic | 1.4795 | Prob. F(4,1554) | 0.2059 |
| Obs*R-squared | 5.9486 | Prob. Chi-Square(4) | 0.2030 |

From the tables 13.1 to 13.3, it can be observed that the p-value for all the three models, 0.4781, 0.8554 and 0.2059 respectively, is more than 0.05, thereby accepting the null hypothesis that for the models derived above, there is no serial correlation among the residuals.

## Test of Causality

Further, we run the Granger Causality among the variables, to identify the direction of causality in the asset classes. Results of Granger Causality test are reported in Tables 14.1, 14.2 and 14.3. We test the null hypothesis that one series does not Granger Cause another series at the conventional levels of significance. On testing the Granger Causality among CF-SPOT, we do not accept both the null hypothesis as the p-values are less than 0.05. So we accept both the alternate hypotheses that SPOT granger cause CF and CF granger cause SPOT depicting that there is a bi-directional relationship between CF and SPOT.

**Table 14.1: Pairwise Granger Causality Test for CF and Spot**

| Null Hypothesis: | Lags | Obs | F-Statistic | Prob. |
|---|---|---|---|---|
| SPOT does not Granger Cause CF | 8 | 1565 | 18.9045 | 0.0000 |
| CF does not Granger Cause SPOT | | | 50.2864 | 0.0000 |

**Table 14.2: Pairwise Granger Causality Test for CF and Equity**

| Null Hypothesis: | Lags | Obs | F-Statistic | Prob. |
|---|---|---|---|---|
| EQUITY does not Granger Cause CF | 4 | 1569 | 1.6611 | 0.1565 |
| CF does not Granger Cause EQUITY | | | 4.0477 | 0.0029 |

**Table 14.3: Pairwise Granger Causality Test for CF and Bond**

| Null Hypothesis: | Lags | Obs | F-Statistic | Prob. |
|---|---|---|---|---|
| BOND does not Granger Cause CF | 4 | 1568 | 1.8833 | 0.1108 |
| CF does not Granger Cause BOND | | | 6.5299 | 0.0000 |

As in the above table 14.2, p-value of 0.1565 > 0.05, accepts the null hypothesis that equity does not granger cause commodity future. For the next hypothesis, we accept the alternate hypothesis that commodity futures granger cause equity as p-value of 0.0029 <0.05. We can say that there is a unidirectional relationship between commodity futures-equity. Similarly on testing the causality among CF and bond, we accept the first null hypothesis that Bond does not granger cause CF as probability value of 0.1108 is more than 0.05. On the other hand, we accept the alternate hypothesis of CF granger cause Bond as p-value is less than 0.05. Hence there is a unidirectional relation between the two.

## Sharpe Ratio

It is a measure of portfolio's excess return relative to the total variability of the portfolio. An asset that has higher Sharpe ratio means that an investor would earn higher return per unit of risk as compared to another asset that has lower Sharpe Ratio. Table 15 presents the daily Expected Returns, Standard Deviation and Sharpe ratio for different asset classes. The mean return among all the assets is highest for MCX Metal. It is evident that the returns for commodity futures are higher as compared to equity and bond with an exception to MCX Energy. The rationale being that the factors driving the commodity prices are different from the factors driving the equity and bond prices. From the table, MCX COMDEX and MCX Agri have similar level of risk- return profile. The Sharpe ratio is highest for MCX Metal, followed by other commodity indices. So, to include commodity futures into a portfolio we would next determine the optimal risky portfolio that would yield maximum return and lowest risk using MVO.

**Table 15: Sharpe Ratios (%) for the Period 2005-2011**

| Asset Class | Expected Return | Standard Deviation | Sharpe Ratio |
|---|---|---|---|
| **S & P CNX Nifty** | 11.1899 | 25.3670 | 0.4411 |
| **NSE G-Sec** | 3.1570 | 22.0239 | 0.1433 |
| **MCX COMDEX** | 12.4696 | 17.2114 | 0.7245 |
| **MCX Energy** | 8.6996 | 27.6124 | 0.3150 |
| **MCX Metal** | 16.3139 | 19.9074 | 0.8194 |
| **MCX Agri** | 12.5749 | 17.7833 | 0.7071 |

## Portfolio Construction

The optimal risky portfolios A, B and C are determined using constrained optimized technique. Portfolio A is a traditional portfolio that includes equity and bond, whereas, Portfolio B consists of equity, bond and commodity futures as the assets. In Portfolio C, apart from equity and bond, it includes the three sub indices, MCX AGRI, MCX METAL and MCX ENERGY are taken as proxy to commodity futures. Table 16, 17 and 18 depicts the set of risky portfolios at varying levels of risk and return for portfolio A, B and C respectively. The portfolio with the highest Sharpe ratio tangent to CAL is the optimal risky portfolio.

**Table 16: Risk-Return Profile for Construction of Efficient Frontier for Portfolio A (without Commodity Futures)**

| **Risk/ Return** | **Portfolios** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3*** | **A4** | **A5** | **A6** | **A7** |
| Expected Return | 0.07700 | 0.08100 | **0.09999** | 0.10500 | 0.11000 | 0.12000 | 0.13000 |
| SD | 0.16756 | 0.17103 | **0.20343** | 0.21536 | 0.22831 | 0.25666 | 0.28745 |
| Sharpe Ratio | 0.45952 | 0.47361 | **0.49157** | 0.48755 | 0.48179 | 0.46754 | 0.45225 |
| **Weights** | | | | | | | |
| S&P CNX Nifty | 0.51968 | 0.56544 | **0.78277** | 0.83998 | 0.89717 | 1.01156 | 1.12596 |
| NSE G-Sec | 0.48032 | 0.43456 | **0.21723** | 0.16002 | 0.10282 | 0.01157 | 0.12596 |

* Optimal risky portfolio without commodity futures

As evident from the tables, the optimal risky portfolio without commodity futures (A) has a lower Sharpe ratio of 46.62% as compared to 82.26% for portfolio that has a composite commodity futures index (B). However, Portfolio C has the maximum Sharpe ratio of 111.76% among the three risky portfolios.

So, to earn highest return per unit of risk, an investor should hold MCX Metal & MCX Agri in a portfolio of equity and bond (C4) as compared to holding a composite index MCX COMDEX, which is still higher than holding only equity and bond in the portfolio.

**Table 17: Risk-Return Profile for Construction of Efficient Frontier for Portfolio B (with Commodity Futures)**

| Risk/ Return | Portfolios | | | | | | |
|---|---|---|---|---|---|---|---|
| | **B1** | **B2** | **B3*** | **B4** | **B5** | **B6** | **B7** |
| Expected Return | 0.10000 | 0.11100 | **0.11299** | 0.11500 | 0.11700 | 0.12000 | 0.13000 |
| SD | 0.12620 | 0.13500 | **0.13735** | 0.13991 | 0.14267 | 0.14714 | 0.16459 |
| Sharpe Ratio | 0.79238 | 0.82222 | **0.82268** | 0.82193 | 0.82008 | 0.81553 | 0.78984 |
| **Weights** | | | | | | | |
| S&P CNX Nifty | 0.21099 | 0.23681 | **0.24149** | 0.24619 | 0.25088 | 0.25793 | 0.28139 |
| NSE G-Sec | 0.25226 | 0.13256 | **0.11080** | 0.08903 | 0.06728 | 0.03462 | -0.07420 |
| MCX COMDEX | 0.53675 | 0.63063 | **0.64769** | 0.66478 | 0.68184 | 0.70745 | 0.79281 |

* Optimal risky portfolio with commodity futures

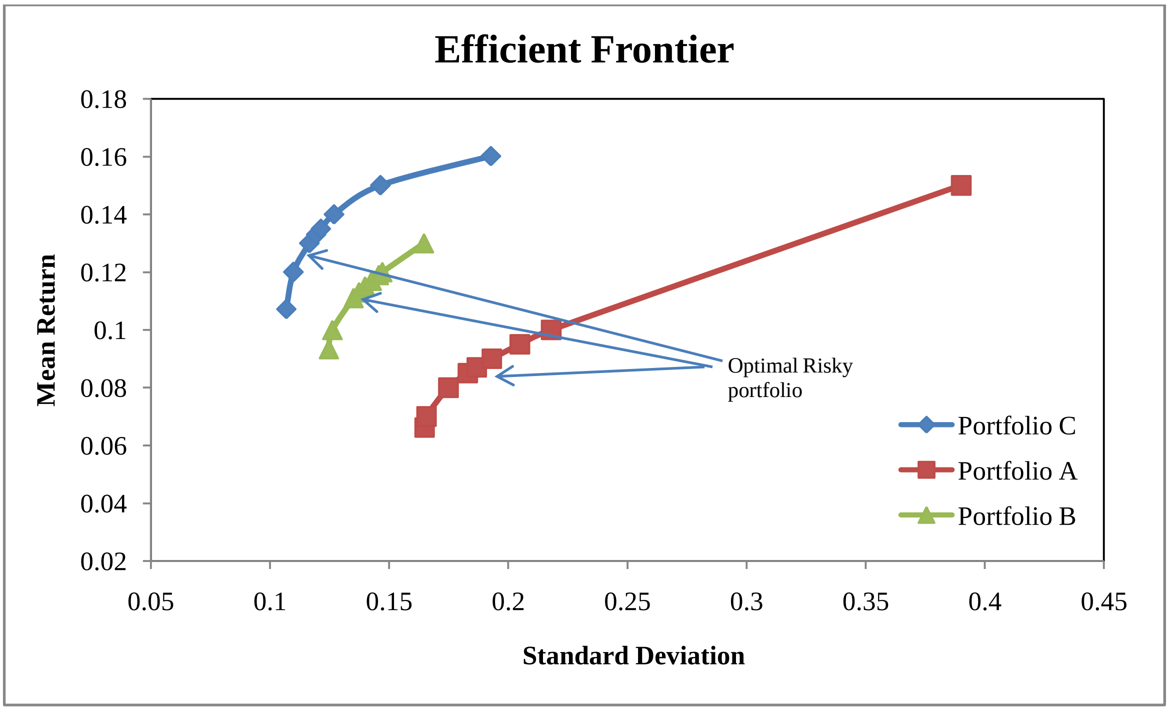
**Table 18: Risk-Return profile for construction of efficient frontier for Portfolio C (with commodity futures sub indices)**

| Risk/Return | Portfolios | | | | | | |
|---|---|---|---|---|---|---|---|
| | **C1** | **C2** | **C3** | **C4*** | **C5** | **C6** | **C7** |
| Expected Return | 0.10717 | 0.12000 | 0.13000 | 0.13299 | 0.13500 | 0.14000 | 0.15000 |
| Standard Deviation | 0.10679 | 0.10981 | 0.11632 | 0.11900 | 0.12096 | 0.12639 | 0.14636 |
| Sharpe ratio | 1.00353 | 1.09276 | 1.11759 | 1.11761 | 1.11607 | 1.10760 | 1.02483 |
| **Weights** | | | | | | | |
| S & P CNX Nifty | 0.14511 | 0.14845 | 0.14544 | 0.14403 | 0.14308 | 0.14074 | 0.03058 |
| NSE G-Sec | 0.24172 | 0.16237 | 0.08707 | 0.06326 | 0.04738 | 0.00768 | 0.00000 |
| MCX Energy | 0.05289 | 0.00812 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| MCX Metal | 0.22045 | 0.31864 | 0.38688 | 0.406613 | 0.41976 | 0.45263 | 0.65992 |
| MCX Agri | 0.33982 | 0.36242 | 0.38059 | 0.38610 | 0.38977 | 0.39895 | 0.30949 |

* Optimal risky portfolio including commodity futures sub-indices

As per Figure 7, on constructing the efficient frontier for all the three set of portfolios, it can be seen that the risk dispersion for portfolio A is very high as compared to portfolio B and C. Thus, adding commodity futures to a portfolio of equity and bond does improve the return and lower the risk. However, we need to find whether including a composite index would yield better returns or the sub-indices. So on comparing the portfolio B and C, at the same level of risk portfolio C, that includes commodity futures sub-indices yields higher return as compared to the portfolio B that includes only a composite index. Thus by investing in the optimal risky portfolio C, an investor can earn maximum return per unit of risk along with the benefits of diversification.

**Figure 7: Efficient Frontier for the Portfolios A, B and C**




Therefore, an investor would get the best risk-return trade off by including MCX Ari and MCX Metal to a traditional portfolio mix of equity and bond. The next step is the capital allocation among risky portfolio and risk free portfolio with the objective of maximization of utility. Using the equations 27 and 28 in section 4.4, the weight of risky portfolio as against the risk free portfolio is computed for different type of investors by changing the risk aversion levels and determining the portfolio utility. The portfolio so attained would give investor the maximum utility.

A risk neutral investor's decisions are not affected by the degree of uncertainty in a set of outcomes, so he is indifferent between choices with equal expected payoffs even if one choice is riskier while, an aggressive investor has willingness to accept above-average risk in pursuit of above-average return. And, a conservative investor plays cautiously having a risk-averse investment strategy which has preservation of capital as a high priority.

**Table 19: Maximizing the Utility with Inclusion of MCX COMDEX (2005-2011)**

| Type of Investor/ Asset | S&P CNX Nifty | NSE G-Sec | MCX COMDEX | NSE TB | Exp Utility | Exp Return | SD | Sharpe Ratio |
|---|---|---|---|---|---|---|---|---|
| **Risk Neutral (A=0)** | 100.00 | 0.00 | 0.00 | 0.00 | 11.30 | 11.89 | 25.37 | 46.87 |
| **Aggressive (A=1)** | 69.00 | 31.00 | 0.00 | 0.00 | 10.36 | 8.70 | 18.68 | 46.57 |
| **Moderately Aggressive (A=2)** | 34.57 | 15.86 | 49.57 | 0.00 | 9.41 | 10.55 | 13.58 | 77.69 |
| **Moderately Conservative (A=3)** | 23.05 | 10.57 | 61.82 | 4.56 | 8.47 | 10.89 | 13.11 | 83.07 |
| **Conservative (A=4)** | 17.29 | 7.93 | 46.36 | 28.42 | 7.53 | 9.64 | 9.83 | 98.07 |

*Note:* All the values are in %

From table 19, it is evident that with the increase in investor's risk aversion levels, the allocation to commodity futures also increases. A risk neutral investor judges the investment solely on the basis of return; therefore would not seek to add commodity futures to reduce risk. To maximise the utility, an aggressive investor (A=1) should allocate 69% to equity and 31% to bonds. Comparatively, for a moderately aggressive investor (A=2), 49.57% of allocation in commodity futures would maximize the utility. This exposure to commodity futures reduces the overall portfolio risk. Similarly, a moderately conservative investor commits 23.05% to equity, 10.57% to bonds, 4.56% in T-bill and 61.82%, in commodity futures. In this portfolio, adding commodity futures reduces the portfolio risk and increases the return, thereby providing some diversification benefit. For a conservative investor, although there is risk reduction but reducing the allocation in commodity futures has also lowered the returns.  In addition, it can also be interpreted that with the increase in risk aversion levels, the Sharpe ratio is also increasing, thereby showing the diversification benefits of including commodity futures to a traditional portfolio consisting of equity and bond.

# CHAPTER-6

# RESULTS OF THE STUDY

The study empirically examines the proposition that whether commodity futures can be treated as an alternative asset for risk-averse investor by including it to a traditional portfolio mix of equity and bond by using the data across 2005-2011. This is done by evaluating the short run and long run relationship of commodity futures with other asset classes and comparing the respective returns on the portfolio by including the composite commodity futures index.

**Hypothesis 1: There is no significant difference between returns of commodity futures and commodity spot market.**

From the Table 3, the correlation between the prices of commodity futures and commodity spot is very high 0.99826 and significant.

**Table 20: t-Test: Paired Two Sample for Means for CF and Spot**

| | ***CF*** | ***SPOT*** |
|---|---|---|
| Mean | 0.05392 | 0.06003 |
| Variance | 1.46324 | 1.70043 |
| Observations | 1504 | 1504 |
| Hypothesized Mean Difference | 0 | |
| t Stat | -0.17974 | |
| P(T<=t) two-tail | 0.85738 | |
| t Critical two-tail | 1.96154 | |

Further, the long run co-movement between the two can be comprehended from the tables 7.1 and 14. It can be identified that both the trace test and max-eigen test have probability of more than 0.05, therefore signifying that there is a long term co-integration between the commodity futures and spot prices. Additionally, the granger causality tests indicate that both the price series granger cause each other.

From the above results, it can be implied there is no significant difference between returns of commodity futures and commodity spot. As a result, the null hypothesis cannot be rejected. Commodities have long been neglected by the investors due to lack of investment access. However, commodities offer the benefits of hedging, high leverage and more trading hours, over equity and bond market.

**Hypothesis 2: There is no significant difference among price movement of commodity futures, equity and bond.**

From the Tables 3, 8.2, 9.2 and 15, it is evident that there is a significant low correlation between commodity futures and equity, whereas there is a significant negative correlation among commodity futures and bond. Further, the long term co-integration between the variables is analysed and the results confirm that there exists no long term co-integration among commodity futures and equity, whereas one co-integration equation exist among commodity futures and bond.

Also, there is a unidirectional relationship of commodity futures with equity and bond, wherein, commodity futures granger cause equity and bond granger cause commodity futures. These results are substantiated by VAR/VECM models.

As a result, it can be inferred that there is a significant difference among price movement of commodity futures with equity and bond, thereby, rejecting the null hypothesis.

**Hypothesis 3: There is no significant correlation between commodity future and inflation.**

From the Table 3, it is evident that there is a significant negative correlation (-0.294) among the Wholesale Price Index (WPI) and MCXCOMDEX at 1% significance level. Therefore, it can be inferred that commodity futures can be treated as a hedge against inflation. The key argument is that during the periods of unexpected inflation, the value of equity and bond tends to decrease, whereas commodity holdings rise in price with inflation. Thus, commodity acts as a natural hedge against unexpected price rise.

**Hypothesis 4: The allocation to commodity futures in the portfolio does not change with the change in risk aversion levels for maximizing the utility.**

From the tables 16, 17 and 18 the optimal portfolios are achieved at a level that gives the maximum Sharpe Ratio for all the three portfolios, one, consists of only traditional assets, second includes commodity composite index and third portfolio includes commodity sub-indices. Later in table 19, the weights of the assets in the portfolio are determined for investors with different risk aversion levels, and it can be implied that the weights of commodity futures is different at all the levels. A risk neutral investor is not affected by the degree of uncertainty; therefore he would invest 100% in Equity, if we are considering the composite index otherwise 100% in MCX Energy, if we are including sub-indices to the traditional portfolio. With the reducing appetite of investors towards the risk, the weightage of commodity in the portfolio increases with simultaneous increase in Sharpe Ratio. As a result we cannot reject the alternate hypothesis that allocation to commodity futures in the portfolio changes with the change in risk aversion levels of the investor.

Drawing on the analysis, the findings of the study are:

Commodity futures and commodity spot prices cointegrate in long run, implying that the two price series converge in long term. So an investor can include either of the two in the portfolio, but since the variance in commodity future returns is low, commodity futures have low transaction cost, low storage cost and return is high for commodity futures as compared to commodity spot, therefore one is better off by including it in the portfolio. The choice between the two, whether to invest in commodity futures or spot depends on the need of the investor, who wants to take the delivery at the end of the contract may wish to invest in spot rather than futures and an investor who does not want to take delivery, is investing to earn the returns, does not have huge amount to invest and wants to square-off the position should invest in futures. And the movement of spot returns with other asset classes is same as movement of futures with rest of the assets.

Commodity futures have high returns and low risk when compared to equity. Based on the co-integration results, it is identified that commodity futures and equity do not have a long term association, meaning that the two series do not share a common stochastic drift. And there is a unidirectional relationship between the two, commodity futures granger cause equity. Commodity futures have a significant low correlation with equity and statistically significant negative relationship with bond, making it a feasible option to be considered as an asset class. Therefore, an investor with an objective of long term horizon should include commodity futures to reap the benefits of diversification.

Sharpe Ratio for standalone asset is highest for MCX COMDEX as compared to S&P CNX Nifty, implying that if an investor holds a single asset in the portfolio, the return per unit of risk is high for commodity futures as compared to equity as MCXCOMDEX has higher return and low risk. The optimal risky portfolio without commodity futures has a lower Sharpe ratio of 49.16% as compared to 82.27% for portfolio with composite commodity futures index but is maximum 111.76% for the portfolio that has commodity sub-indices. In portfolio C, the optimal level that would give maximum Sharpe Ratio, suggests that investor should hold MCX AGRI and MCX METAL in addition to equity and bond and should not hold MCX ENERGY as its risk component is highest. Only a risk neutral investor would invest 100% in MCX Energy to earn maximum return. On constructing the efficient frontiers, it can be seen that the risk dispersion for traditional portfolio is very high as compared to portfolio that includes commodity futures. Drawing the corollary from the above, it can also be treated as a standalone investment tool for a risk neutral investor.

On inclusion of commodity futures to a traditional portfolio, the mean return increases for a risk-averse investor for the reason that it has a significant negative correlation with bond and a low correlation with equity. With the increase in risk aversion levels, allocation to commodity futures increases with a simultaneous increase in the Sharpe ratio. So for a risk-averse investor the desire for high return- low risk and maximizing utility can be achieved by investing in commodity futures.

Consequently, the risk-averse Indian investor with an aim to diversify risk and enhance the return, is better off by holding a commodity futures composite index, MCX COMDEX in the portfolio of equity and bond. In view of the fact that, commodity futures has a low short term correlation with the traditional assets and also that equity does not move in sync with commodity futures in long term. And, by including a non-cointegrating asset to the portfolio would improve the overall returns. Therefore, the results of the analysis do support the diversifying properties of commodity futures on inclusion into the traditional portfolio with the ability to maximize the investor’s utility and can be considered as an alternative asset class.

# CHAPTER-7

## CONCLUSIONS AND RECOMMENDATIONS

The investigation of the commodity as an asset class has led to the conclusion that commodity futures offer attractive risk/return profile and diversification benefits, and as such, should be complementary to traditional portfolio of stocks and bonds, if the end goal is to improve portfolio efficiency. The recommendation of this study is strategic, not tactical. The study does not have a view as to whether commodities are overvalued or positioned to benefit from a secular bull market and investing in individual commodities will also offer the similar portfolio benefits as investing in an index. The study concludes that investors should consider commodities due to the risk/return and diversification benefits of the asset class depending upon specific needs and preferences of each investor. The other ancillary benefits of considering investments in commodity futures are ease of transacting (buying and selling) in futures market during extended hours as the commodity market operates from 10 am to 11:55 pm. Since the volume of trading has increased by commendable levels in commodity futures, this increased liquidity would help the investor in low cost switching from one commodity to another. Also, transactions in gold futures are not considered 'speculative' under Section 43(5) of the Income Tax Act, enabling the investor to set off his business loss/profits with the profits/loss made in the futures market, thereby lowering his tax liability.

For a country like India, an agriculture surplus economy, the existence of commodity futures market provides it more strength. The commodity exchanges ensure efficiency in terms of price discovery, growth and transparency of the commodity futures markets, by offering trading platform to the producers and consumers in various commodities. The exchanges achieve this role by the functions, infrastructure capabilities, trading procedures, settlement and risk management practices. However, Indian commodity exchanges are still at a developing stage as there are numerous bottlenecks that obstruct their growth. There are various issues at institutional and policy-levels, associated with commodity exchanges that remain unaddressed by the government. It should coordinate with FMC and take necessary measures to bring about a significant expansion and development of the commodity futures markets. Some of the major areas of dilemma are the lack of efficient and sophisticated infrastructural facilities, open outcry system for trading followed by regional exchanges, non-integration of regional exchanges with the national exchanges and controlled market for many commodities by ECA, 1955. Integration of regional exchanges with national exchanges will make possible to achieve price discovery for regional exchanges as the broad-level prices prevailing at the national exchanges will help in driving the commodity prices at regional level. The integration of the spot and futures market is another critical factor for the expansion of the commodity futures market in India.

Despite so many constraints, Foreign Institutional Investors (FIIs), mutual funds and banks may be allowed to actively participate in the Indian commodity derivatives markets. The Reserve Bank of India (RBI), along with the Ministry of Finance and Consumer Affairs, is considering a proposal to grant permission to overseas institutional investors to participate in the Indian commodity derivatives markets (Business Standard, 10 December, 2014). Allowing the international institutional investors to participate in the Indian commodity futures market brings with them certain advantages and drawbacks. Their participation will bring the much needed breadth and depth to the futures market, the transaction cost can be reduced, turnover in the futures market will improve that was hampered after the introduction of Commodity Transaction Tax and NSEL Scam. This would improve the liquidity of the futures market, improve the price discovery mechanism and will help in building confidence among the traders that would eventually increase the investment base. Moreover, with this move, commodity derivatives market will converge with the financial derivatives markets to reap better gains for the investors. The Economic Survey for 2004-05 (pp.188) has rightly articulated that the convergence of commodity futures markets with other derivatives markets will induce eminent economies of scale and stressed that, ‘this convergence would help in the efficient utilisation of capital and institution building, which has already taken place for the derivatives markets for the purposes of India’s agricultural sector’. But FII investment in commodity market can have a negative impact on the spot prices as it influences the stock market.

Another significant recommendation is the reintroduction of options trading in commodities. Since futures trading protects the farmers by hedging the downside price fluctuations but it does not allow the benefit of upside. Therefore, it is recommended to allow trading in options as it provides the advantage of an upside to the farmers if prices are higher during harvest. Options are relatively simple to use for hedging the price risk. An option contract gives the holder the right and not the obligation to sell/buy the commodity at the time of maturity. A call option gives the holder the right to buy the underlying commodity and put option gives him the right to sell the underlying commodity. If the producer enters into a put option to sell the commodity at a price favourable to him in near future and at the time of maturity if price fall from the decided price, he goes through with the contract of selling, but if price increases, he need not sell and forfeits the premium. Similarly, a call options gives the same advantage without any obligation to buy the commodity. Therefore, options is an appealing avenue for price risk hedging than futures to the farmers. Therefore, the next reform required in commodity market is to bring option trading in commodities.

## 7.1 IMPLICATIONS FOR THE BANKS

The participation of banks in commodity futures market will help in strengthening of financial sector, that will lead to increased savings and economic growth. Their participate in

Indian commodity futures market would not only stimulate the growth of commodity trading but will also open new avenue of investment for farmers and other stakeholders who are currently not able to reap the benefits of commodities. Banks act as a catalyst between financial sector and real economy. Banks in India provide finance to commodity business, fund and non-fund based services to commodity traders to meet their working capital requirements. Banks exposure to rising volatility in commodity prices is quite high at 19 percent annualised rate of the total outstanding lending to commodity oriented sectors (Economic Times, June, 2014). In light of this, banks should be allowed to participate in commodity futures market, it would bring more depth to the market and also hedge their exposure to commodity based lending from frequent price fluctuations, which is specific to agriculture industry. With this measure, banks will be able to free their financial resources helping them to achieve priority sector targets and expansion of overall banking business.

When farmers take loan on commodity from the banks, they have to pay back the loan before making the sale contract of that commodity. Banks and exchanges can contribute in a way that exchanges holding the realised amount from the sale proceeds should first discharge the loan to the bank and then credit the balance to the farmer. Thus would help in penetrating the banking access till the last mile. Banks can also act as aggregators to the individual farmers who find it difficult to enter the commodity futures market.

But these benefits could only be reaped with the strengthening of the regulatory system, adequately trained manpower and reforms in the current regulations to prevent distortions in the commodity market and curb inflationary pressures.

## 7.2 IMPLICATION FOR INVESTORS/ MUTUAL FUNDS/MSME

With the increasing fluctuations in the financial markets, the investor looks upon for new investment tool, to well diversify their portfolios. Among the varied financial products available in the market, this study has tried to examine the diversifying properties of commodity futures on adding to the traditional portfolio of equity and bond. As commodity being a real asset, its basic properties of price and risk determination differs from financial assets like equity and bond. From the analysis, it can be inferred that commodity futures and equity do not move in sync in long term and there is no integration among the two. So, by including non-integrating assets would yield better returns. The Sharpe Ratio of commodity futures is very high when compared to equity and bond, therefore its inclusion will lower the portfolio risk and enhance the returns for the investor. The study has also tried to identify the allocations that can be made by investor to maximize the return at different levels of risk aversion.

On account of high unpredictability of long term inflation rates, investments alone in traditional assets like equity and bond cannot protect the portfolio returns. Commodities are often seen as a hedge against inflation since commodity prices respond directly to the economic factors that determine inflation. While, this trend is inverse in case of traditional assets, equity and bonds. With the increasing interest rates, cost of borrowing is high that reduces the earning per share for the companies. Therefore, investment in commodity futures is a rewarding option for the investors who want to diversify their portfolio beyond equity and bond. For Mutual fund managers, the investment in this asset class will help them reap better returns during the inflationary periods when the equity prices are in bullish trend. Investors can use the futures route to better manage their asset allocation, improve overall portfolio returns while managing risks within their risk tolerance limits.

The study recommends an investor to include commodity futures to their traditional portfolio for diversification of risk. A risk neutral investor, who is indifferent towards the degree of risk, should invest 100% in equity or commodity futures to maximise the returns. An aggressive investor would be able to earn 46.57% of sharpe ratio if invests 69% in equity and 31% in bond. The sharpe ratio increases with the inclusion of commodity futures to the traditional portfolio of equity and bond. The proportion of commodity futures in the portfolio impacts the degree of portfolio return. Similarly, a moderately conservative investor should commit 23.05% to equity, 10.57% to bonds, 4.56% in T-bill and 61.82%, in commodity futures to earn a return of 10.89%. The benefits of adding commodity futures to a portfolio can be used by mutual funds for hedging the overall risk and enhancing the returns for the investor.

## 7.3 LIMITATIONS OF THE STUDY

The modern portfolio theory suggests that adding uncorrelated assets to the portfolio would yield higher returns. This diversification can be achieved by many financial and real assets available in the financial market like corporate bonds, sovereign bonds, equity derivatives, currencies, real estate, venture capital, private equity, etc. The options for diversification are enormous, thus, exploring all these options would be beyond the scope of this study, therefore, the analysis to commodity spot, equities, and bonds are delimitated.

For examining commodity future as an asset class the study has considered only composite index (MCXCOMDEX) as a proxy, therefore due care should be taken while making generalization from the results of the study. Since the introduction of commodity futures for online trading in India opened up only in (2003), therefore the data is constrained to the specified period (2005-2011).

Another limitation of the study is the barriers faced by the investor while investing in the commodity futures market. These barriers are the insufficient knowledge to the investor for investment, lack of technical know-how of investing in commodity futures, not fully developed commodity market, commodity prices are vulnerable to seasonal fluctuations, large fluctuations in the commodity prices can lead to high margin calls and accordingly greater losses.

There are many investment strategies that an investor uses for trading as buy and hold strategy, pair strategy, momentum strategy, long-short strategy based on contango and backwardation. But the results of this study are oriented towards the investor who uses only the buy and hold strategy.

## 7.4 FUTURE SCOPE OF STUDY

The study can be considered for future research by comparing the commodity futures as an asset class in international perspective and its diversifying properties can be verified globally.

In addition, the study has reflected the diversifying properties of commodity futures for a composite index and sub indices, whereas the individual commodities can also be considered for reducing the risk and enhancing the return. Portfolios could also be constructed by considering individual commodities for the diversifying properties. Furthermore, the inflation is a global concern which affects the return. Therefore, the extension of this study could also look at the behaviour of commodity futures as an asset class during different phases of inflationary conditions.

However, the present study has enriched the understanding of commodity futures as an asset class in Indian context which can be further analysed in future for the purpose of diversifying investor's portfolio to maximise the returns in conjunction with other investment tools as exploring various trading strategies.

## 7.5 LIST OF PUBLICATIONS

### Paper Published in Journals:

i. Bansal, Y., Kumar, S., & Verma, P. (2014). Commodity Futures in Portfolio Diversification: Impact on Investor's Utility. *Global Business and Management Research: An International Journal*, 6(2), 112-121.

ii. Bansal, Y., Kumar, S. and Verma, P. (2014). Co-Integration and Causality between Equity and Commodity Futures: Implications for Portfolio Diversification. *Global Journal of Management and Business Research* (C ), 14(5), 35-45.

### Paper Presented in Seminars/Conferences:

i. Bansal. Y, Shailendra. K, Piyush. V., "Inclusion of Commodity Futures for portfolio diversification: An empirical evidence", India Accounting and Finance Conference, IIM Lucknow, 09.09.13 to 11.09.13

ii. Bansal. Y, Shailendra. K, Hemant. S., "Indian Commodity Futures: A diversifying tool for investors", AICTE Sponsored Conference on Management Practices to Combat Recession, Swami Vivekanand Institute of Engineering and Technology, Banur, 06.03.14 to 08.03.14.

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## APPENDIX A: Results of Monthly Data for all the four Price Indices

### 1. Unit Root Results for Monthly Data

**Table A1.1: Unit Root results for M_CF**

| Null Hypothesis: M_CF has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -1.974900 | 0.2972 |
| Test critical values: | 1% level | -3.515536 | |
| | 5% level | -2.898623 | |
| | 10% level | -2.586605 | |

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

**Table A1.2: Unit Root results for D(M_CF)**

| Null Hypothesis: D(M_CF) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -4.128752 | 0.0015 |
| Test critical values: | 1% level | -3.516676 | |
| | 5% level | -2.899115 | |
| | 10% level | -2.586866 | |

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

**Table A1.3: Unit Root results for M_Spot**

| Null Hypothesis: M_SPOT has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -2.435918 | 0.1354 |
| Test critical values: | 1% level | -3.516676 | |
| | 5% level | -2.899115 | |
| | 10% level | -2.586866 | |

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

**Table A1.4: Unit Root results for D(M_Spot)**

| Null Hypothesis: D(M_SPOT) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -3.862688 | 0.0036 |
| Test critical values: | 1% level | -3.516676 | |
| | 5% level | -2.899115 | |
| | 10% level | -2.586866 | |

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

**Table A1.5: Unit Root results for M_Equity**

| Null Hypothesis: M_EQUITY has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -2.360137 | 0.1564 |
| Test critical values: | 1% level | -3.519050 | |
| | 5% level | -2.900137 | |
| | 10% level | -2.587409 | |

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

**Table A1.6: Unit Root results for D(M_Equity)**

| Null Hypothesis: D(M_EQUITY) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -3.488615 | 0.0109 |
| Test critical values: | 1% level | -3.519050 | |
| | 5% level | -2.900137 | |
| | 10% level | -2.587409 | |

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

**Table A1.7: Unit Root results for M_Bond**

| Null Hypothesis: M_BOND has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -1.464154 | 0.5465 |
| Test critical values: | 1% level | -3.515536 | |
| | 5% level | -2.898623 | |
| | 10% level | -2.586605 | |

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

**Table A1.8: Unit Root results for D(M_Bond)**

| Null Hypothesis: D(M_BOND) has a unit root | | | |
|---|---|---|---|
| | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -6.006332 | 0.0000 |
| Test critical values: | 1% level | -3.516676 | |
| | 5% level | -2.899115 | |
| | 10% level | -2.586866 | |

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

## 2. Johansen Co-integration Results

**Table A2.1: Results of Johansen Co-integration between Monthly Commodity Future prices & Monthly Commodity Spot Prices**

| **Unrestricted Cointegration Rank Test (Trace)** | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 2 | | | | |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None *** | 0.208919 | 22.83319 | 15.49471 | 0.0033 |
| **At most 1*** | 0.060286 | 4.787875 | 3.841466 | 0.0287 |
| Trace test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| **Unrestricted Cointegration Rank Test (Maximum Eigenvalue)** | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None *** | 0.208919 | 18.04531 | 14.26460 | 0.0120 |
| **At most 1*** | 0.060286 | 4.787875 | 3.841466 | 0.0287 |
| Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| Long Run Johansen Cointegration Equation | |
|---|---|
| 1 Cointegrating Equation(s): | Log likelihood -833.8011 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | |
| **M_CF** | **M_SPOT** |
| 1.000000 | -1.002970 |
| | (0.00874) |
| Adjustment coefficients (standard error in parentheses) | |
| D(M_CF) | -0.034268 |
| | (1.06692) |
| D(M_SPOT) | 0.386660 |
| | (1.08187) |

**Table A2.2: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF prices and Monthly Commodity Spot Prices**

| Lag: 2 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 22.83319 | 15.49471 | 0.0033 | 18.04531 | 14.26460 | 0.0120 |
| **r≤1** | 4.787875 | 3.841466 | 0.0287 | 4.787875 | 3.841466 | 0.0287 |

**Table A2.3: Results of Johansen Cointegration between Monthly Commodity Future Prices & Monthly Equity Prices**

| Unrestricted Cointegration Rank Test (Trace) | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 5 | | | | |
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.104203 | 13.83837 | 15.49471 | 0.0875 |
| **At most 1*** | 0.074076 | 5.695306 | 3.841466 | 0.0170 |
| Trace test indicates no cointegration at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| **Unrestricted Cointegration Rank Test (Maximum Eigenvalue)** | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.104203 | 8.143059 | 14.26460 | 0.3644 |
| **At most 1*** | 0.074076 | 5.695306 | 3.841466 | 0.0170 |
| Max-eigenvalue test indicates no cointegration at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| **Long Run Johansen Cointegration Equation** | |
|---|---|
| 1 Cointegrating Equation(s): | Log likelihood -990.2288 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | |
| **M_CF**<br>1.000000 | **M_EQUITY**<br>-0.442935<br>(0.09911) |
| Adjustment coefficients (standard error in parentheses) | |
| **D(M_CF)** | -0.228817<br>(0.08739) |
| **D(M_EQUITY)** | -0.026679<br>(0.13293) |

**Table A2.4: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF Prices and Monthly Equity Prices**

| Lag: 5 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 13.83837 | 15.49471 | 0.0875 | 8.143059 | 14.26460 | 0.3644 |
| **r≤1** | 5.695306 | 3.841466 | 0.0170 | 5.695306 | 3.841466 | 0.0170 |

**Table A2.5: Results of Johansen Cointegration between Monthly Commodity Future Prices & Monthly Bond Prices**

| **Unrestricted Cointegration Rank Test (Trace)** | | | | |
|---|---|---|---|---|
| Lags interval (in first differences): 1 to 2 | | | | |
| **Hypothesized No. of CE(s)** | **Eigen Value** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.109624 | 9.864952 | 15.49471 | 0.2913 |
| **At most 1** | 0.011933 | 0.924343 | 3.841466 | 0.3363 |
| Trace test indicates no cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| **Unrestricted Cointegration Rank Test (Maximum Eigenvalue)** | | | | |
|---|---|---|---|---|
| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
| **None** | 0.109624 | 8.940609 | 14.26460 | 0.2911 |
| **At most 1** | 0.011933 | 0.924343 | 3.841466 | 0.3363 |
| Max-eigenvalue test indicates no cointegrating eqn(s) at the 0.05 level | | | | |
| * denotes rejection of the hypothesis at the 0.05 level | | | | |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

| **Long Run Johansen Cointegration Equation** | | | |
|---|---|---|---|
| 1 Cointegrating Equation(s): | | Log likelihood | -754.3994 |
| **Normalized cointegrating coefficients (standard error in parentheses)** | | | |
| **M_CF** | **M_BOND** | | |
| 1.000000 | -12.23631 | | |
| | (5.05842) | | |
| Adjustment coefficients (standard error in parentheses) | | | |
| D(M_CF) | -0.127023 | | |
| | (0.04475) | | |
| D(M_BOND) | -0.000276 | | |
| | (0.00172) | | |

**Table A2.6: Results and Critical Values for the $\lambda_{trace}$ and $\lambda_{max}$ Test for Monthly CF Prices and Monthly Bond Prices**

| Lag: 2 | | | | | | |
|---|---|---|---|---|---|---|
| **Ho** | **Λtrace** | **CV(trace,5%)** | **Prob.** | **Λmax** | **CV(max,5%)** | **Prob.** |
| **r=0** | 9.864952 | 15.49471 | 0.2913 | 8.940609 | 14.26460 | 0.2911 |
| **r≤1** | 0.924343 | 3.841466 | 0.3363 | 0.924343 | 3.841466 | 0.3363 |

## APPENDIX B: GLOSSARY

1. **Asset** Any possession that has value in an exchange.

2. **Asset Allocation Decision** The decision regarding how an institution's funds should be distributed among the major classes of assets in which it may invest.

3. **Asset Classes** Categories of assets, such as stocks, bonds, real estate and foreign securities.

4. **Backwardation** A market condition in which futures prices are lower in the distant delivery months than in the nearest delivery month. This situation may occur in when the costs of storing the product until eventual delivery are effectively subtracted from the price today.

5. **Bear Market** Any market in which prices are in a declining trend.

6. **Bond** Bonds are debt and are issued for a period of more than one year. When an investor buys bonds, he or she is lending money. The seller of the bond agrees to repay the principal amount of the loan at a specified time. Interest-bearing bonds pay interest periodically.

7. **Bull Market** Any market in which prices are in an upward trend.

8. **Call Option** Call options give the option to buy at certain price, so the buyer would want the stock to go up.

9. **Capital Allocation Decision** Allocation of invested funds between risk-free assets versus the risky portfolio.

10. **Capital Market** The market for trading long-term debt instruments (those that mature in more than one year).

11. **Capital Market Line (CML)** The line defined by every combination of the risk-free asset and the market portfolio.

12. **Clearing Member** A member firm of a clearing house. Each clearing member must also be a member of the exchange. Not all members of the exchange, however, are members of the clearing organization. All trades of a non-clearing member must be registered with, and eventually settled through, a clearing member.

13. **Clearinghouse** An adjunct to a futures exchange through which transactions executed its floor are settled by a process of matching purchases and sales. A clearing organization is also charged with the proper conduct of delivery procedures and the adequate financing of the entire operation.

14. **Commodity** A commodity is food, metal, or another physical substance that investors buy or sell, usually via futures contracts.

15. **Commodity Exchange** A commodity exchange is an association, or a company or any other body organizing futures trading in commodities.

16. **Complete Portfolio** The entire portfolio, including risky and risk-free assets.

17. **Correlation Coefficient** A standardized statistical measure of the dependence of two random variables, defined as the covariance divided by the standard deviations of two variables.

18. **Covariance** A statistical measure of the degree to which random variables move together.

19. **Derivative Instruments** Contracts such as options and futures whose price is derived from the price of the underlying financial asset.

20. **Derivative Markets** Markets for derivative instruments.

21. **Derivative Security** A financial security, such as an option, or future, whose value is derived in part from the value and characteristics of another security, the underlying security.

22. **Diversification** Dividing investment funds among a variety of securities with different risk, reward, and correlation statistics so as to minimize unsystematic risk.

23. **Dynamic Asset Allocation** An asset allocation strategy in which the asset mix is mechanistically shifted in response to -changing market conditions, as in a portfolio insurance strategy

24. **Efficient Diversification** The organizing principle of modern portfolio theory, which maintains that any risk averse investor will search for the highest expected return for any level of portfolio risk.

25. **Efficient Frontier** The combinations of securities portfolios that maximize expected return for any level of expected risk, or that minimizes expected risk for any level of expected return.

26. **Efficient Portfolio** A portfolio that provides the greatest expected return for a given level of risk (i.e. standard deviation), or equivalently, the lowest risk for a given expected return.

27. **Emerging Markets** The financial markets of developing economies.

28. **Endogenous Variable** A value determined within the context of a model.

29. **Equity** Represents ownership interest in a firm. Also the residual dollar value of a futures trading account, assuming its liquidation at the going market price.

30. **Exchange** The marketplace in which shares, options and futures on stocks, bonds, commodities and indices are traded.

31. **Exogenous Variable** A variable whose value is determined outside the model in which it is used. Also called a parameter.

32. **Expected Return** The return expected on a risky asset based on a probability distribution for the possible rates of return. Expected return equals some risk free rate (generally the prevailing bond rate) plus a risk premium (the difference between the historic market return, based upon a well diversified index such as the S&P500 and historic Treasury bond) multiplied by the assets beta.

33. **Expected Return on Investment** The return one can expect to earn on an investment.

34. **Financial Market** An organized institutional structure or mechanism for creating and exchanging financial assets.

35. **Futures Contract** Agreement to buy or sell a set number of shares of a specific stock in a designated future month at a price agreed upon by the buyer and seller. The contracts themselves are often traded on the futures market.

36. **Futures Market** A market in which contracts for future delivery of a commodity or a security are bought or sold.

37. **Futures Price** The price at which the parties to a futures contract agree to transact on the settlement date.

38. **Globalization** Tendency toward a worldwide investment environment, and the integration of national capital markets.

39. **Hedge Ratio (delta)** The ratio of volatility of the portfolio to be hedged and the return of the volatility of the hedging instrument.

40. **Hedging** A strategy designed to reduce investment risk using call options, put options, short selling, or futures contracts. A hedge can help lock in existing profits. Its purpose is to reduce the volatility of a portfolio, by reducing the risk of loss.

41. **Inflation** The rate at which the general level of prices for goods and services is rising.

42. **Investments** As a discipline, the study of financial securities, such as stocks and bonds, from the investor's viewpoint. This area deals with the firm's financing decision, but from the other side of the transaction.

43. **Investor** The owner of a financial asset.

44. **Lag** The number of periods that an independent variable in a regression model is "held back" in order to predict the dependent variable.

45. **Markowitz Diversification** A strategy that seeks to combine assets a portfolio with returns that are less than perfectly positively correlated, in an effort to lower portfolio risk (variance) without sacrificing return.

46. **Markowitz Efficient Frontier** The graphical depiction of the Markowitz efficient set of portfolios representing the boundary of the set of feasible portfolios that have the maximum return for a given level of risk. Any portfolios above the frontier cannot be achieved. Any below the frontier are dominated by Markowitz efficient portfolios.

47. **Markowitz Efficient Portfolio** Also called a mean-variance efficient portfolio, a portfolio that has the highest expected return at a given level of risk.

48. **Markowitz Efficient Set of Portfolios** The collection of all efficient portfolios, graphically referred to as the Markowitz efficient frontier.

49. **Mean-Variance Criterion** The selection of portfolios based on the means and variances of their returns. The choice of the higher expected return portfolio for a given level of variance or the lower variance portfolio for a given expected return.

50. **Modern Portfolio Theory** Principles underlying the analysis and evaluation of rational portfolio choices based on risk-return trade-offs and efficient diversification.

51. **Money Market** Money markets are for borrowing and lending money for three years or less.

52. **Opportunity Set** The possible expected return and standard deviation pairs of all portfolios that can be constructed from a given set of assets.

53. **Optimal Portfolio** An efficient portfolio most preferred by an investor because its risk/reward characteristics approximate the investor's utility function. A portfolio that maximizes an investor's preferences with respect to return and risk.

54. **Option** The contract offers the buyer the right, but not the obligation, to buy (call) or sell (put) a security or other financial asset at an agreed-upon price (the strike price) during a certain period of time or on a specific date (exercise date).

55. **Passive Portfolio Strategy** A strategy that involves minimal expectational input, and instead relies on diversification to match the performance of some market index. A passive strategy assumes that the marketplace will reflect all available information in the price paid for securities, and therefore, does not attempt to find mispriced securities.

56. **Passive Portfolio** A market index portfolio.

57. **Portfolio** A collection of investments, real and/or financial.

58. **Probability** The relative likelihood of a particular outcome among all possible outcomes.

59. **Put Option** Put options give the option to sell at a certain price, so the buyer would want the stock to go down.

60. **REIT (real estate investment trust)** Real estate investment trust, which is similar to a closed-end mutual fund. REITs invest in real estate or loans secured by real estate and issue shares in such investments.

61. **Return** The change in the value of a portfolio over an evaluation period, including any distributions made from the portfolio during that period.

62. **Risk** Typically defined as the standard deviation of the return on total investment. Degree of uncertainty of return on an asset.

63. **Risk Averse** A risk-averse investor is one who, when faced with two investments with the same expected return but two different risks, prefers the one with the lower risk.

64. **Risk Lover** A person willing to accept lower expected returns on prospects with higher amounts of risk.

65. **Risk Management** The process of identifying and evaluating risks and selecting and managing techniques to adapt to risk exposures.

66. **Risk Neutral** Insensitive to risk.

67. **Risky Asset** An asset whose future return is uncertain.

68. **Risk-Free Asset** An asset whose future return is known today with certainty.

69. **Sharpe Ratio** A measure of a portfolio's excess return relative to the total variability of the portfolio.

70. **Short Selling** Establishing a market position by selling a security one does not own in anticipation of the price of that security falling.

71. **Speculator** One, who attempts to anticipate price changes and, through buying and selling contracts, aims to make profits.

72. **Spot Price** The current marketprice of the actual physical commodity.

73. **Standard Deviation** The square root of the variance. A measure of dispersion of a set of data from their mean.

74. **Standard Eror** In statistics, a measure of the possible error in an estimate.

75. **Tactical Asset Allocation (TAA)** An asset allocation strategy that allows active departures from the normal asset mix based upon rigorous objective measures of value. Often called active management. It involves forecasting asset returns, volatilities and correlations.

76. **Treasury Bills** Debt obligations of the Indian Treasury that have maturities of one year or less. Maturities for T-bills are usually 91 days, 182 days, or 52 weeks.

77. **Underlying** The "something" that the parties agree to exchange in a derivative contract.

78. **Utility** The measure of the welfare or satisfaction of an investor or person.

79. **Utility Value** The welfare a given investor assigns to an investment with a particular return and risk.

80. **Utility Function** A mathematical expression that assigns a value to all possible choices. In portfolio theory the utility function expresses the preferences of economic entities with respect to perceived risk and expected return.