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EMERGENCE OF COMMODITY DERIVATIVES AS DEFENSIVE INSTRUMENT IN PORTFOLIO RISK HEDGING: A CASE OF INDIAN COMMODITY MARKETS

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Abstract:

This paper empirically examines whether commodity derivatives can be used as an alternative investment asset in India where commodity markets are at emerging state and provides the same diversification benefit as they provide in developed commodity markets. In India only commodity futures are prevalent so various commodity indices representing various sectors has been used in the study. Diversification aspect of commodity derivatives has been tested initially by using correlation analysis. Compounded Daily Growth rate and Relative Standard deviation has been used as a measure of calculating risk and return of daily data of SENSEX, BOND and four Commodity Indices (MCX Comdex, MCX AGRI, MCX Metal, MCX Energy). Markowitz Efficient Frontier theory has been used to calculate portfolio risk return and Sharpe risk adjusted ratio has been used to evaluate the various portfolios. Optimal portfolio has been obtained for the combination of equity, bond and commodity and overall results of the study indicate that an investor who is risk averse will prefer to invest in combination of SENSEX, BOND & MCX Energy whereas an investor who gets utility by taking more risk for more returns will prefer to invest in combination of SENSEX, BOND & MCX Metal. Investor having inclination towards moderate risk return would tend to invest in MCX AGRI along with SENSEX and BOND.

Key words: *commodity derivatives, portfolio risk, Markowitz Efficient Frontier*

1. Introduction

Commodity is defined as a primary product or a raw material that can be bought and sold. It includes agricultural products such as wheat and cattle, energy products such as oil and gasoline, and metals such as gold, silver and aluminum. There are also “soft” commodities, or those that cannot be stored for long periods of time, which include sugar, cotton, cocoa and coffee. Since long commodities have always been considered as consumption asset class and had very negligible role as an investment alternative. In an organized market for a typical investor in India investment options broadly falls into two categories: equity and bonds. Investors whose major

consideration was growth of funds and long term capital gain preferred to make investment in equity markets and investors who are risk averters and interested in fixed returns after regular intervals preferably invest in bond or debt market. Portfolio in that environment involves spread of investment among bond and equity only.

It was only in 2003 that commodities derivative markets with nation-wide connectivity were introduced in India. Although the history of organized commodity derivatives in India goes back to the nineteenth century when Cotton Trade Association started futures trading in 1875, about a decade after they started in Chicago. Over the time derivatives market developed in several commodities in India. Following Cotton, derivatives trading started in oilseed in Bombay (1900), raw jute and jute goods in Calcutta (1912), Wheat in Hapur (1913) and Bullion in Bombay (1920).However many feared that derivatives fuelled unnecessary speculation and were detrimental to the healthy functioning of the market for the underlying commodities, resulting in to banning of commodity options trading and cash settlement of commodities futures after independence in 1952. The commodities future market remained dismantled and remained dormant for about four decades until the new millennium when the Government, in a complete change in a policy, started actively encouraging commodity market. Since 1952 till 2002 commodity datives market was virtually non- existent, except some negligible activities on OTC basis.

The new generation commodities derivative markets introduced in 2003 brought new technology through which trading was conducted for various commodities. Due to the evolution of commodity markets the status of commodities has also been shifted from a consumption asset to the investment asset. They have been started widely used as a tool for hedging and risk management in addition to other investment options. It provides a means to commercial producers and consumers to transfer price risk to speculators and arbitragers who had no direct interest in the commodity. In contrast with financial securities as the direct investment in physical commodities is quite unrealistic and characterized by high transaction, insurance and storage cost. Moreover the factors that drive commodity prices are observed to be different from the factors that drive equity prices. Therefore commodities can be perceived as an alternate asset class and excellent diversifying agents.

Portfolio theory also proposed that the performance of the portfolio can be enhanced by diversifying it to unique asset class. Ideally the portfolio must be allocated among securities having a very low correlation. This will reduces the portfolio risk without decreasing the portfolio returns. Therefore in this study an attempt will be made to explore the emergence of commodity derivatives as a risk diversifying agent in context of the portfolio. In addition to that the inflation rate is heavily dependent on the prices of the commodities. If commodity prices go up, inflation would increase .Increase in commodity prices would result in positive returns on commodity funds. Therefore the second motive of adding commodities to the portfolio is that they might act as inflation proxies in the portfolio. So correlation of all these investment assets with the inflation will also be analyzed in order to evaluate whether commodity derivatives are capable of hedging the portfolio against inflation risk.

2. Review of Literature

Literature on correlation between commodity and equity:

A number of studies had been done in past which concludes that the commodity futures tend to attract the investors due to the fact that they had a low correlation with the equity returns.(Bodie&Rosanky,1980; Irwin and Brorsen,1985;Lee Luthold,&Cordier,1985;Irwin and Landa,1987;Edwards & Park,1996).

Schneeweis and Spurgin (2000) examined the correlations among crude oil futures and stock index, bond index, Real Estate Investment Trust (REITS), and commodity index. Their results confirm negative correlation with the exception of individual periods showing strong variation in leading indicators. In other tests, concerning LMEX and precious metals, the results show the benefits derived by investing in index products on commodities, compared to stock in energy sectors. Edwards and Caglayan (2001) found that commodity funds provide superior downside protection compared to hedge funds. Anson & Mark (2009) determines the utility of investing in commodity futures benchmarked to a commodity futures index. The correlation coefficients presented demonstrate that the returns to commodity futures are consistently negatively correlated with the returns to stocks and bonds and adding commodity futures to a portfolio of stocks and bonds can reduce portfolio volatility.

Furthermore, among the precious metals, gold has the most obvious safe haven effect and a separate line of research is prevalent on depicting the relation between metals and equity. In a study by Jensen, Johnson & Mercer,(2009) benefits of adding precious metals to U.S. equity portfolios has been examined for 34 years. Five major findings have been reported. First, they found that adding a 25% allocation to the equities of precious metals firms improves portfolio performance substantially. Second, their evidence indicates that an indirect investment dominates a direct investment in precious metals. Third, relative to platinum and silver, gold had better stand-alone performance and appears to provide a better hedge against the negative effects of inflationary pressures. Fourth, the benefits of precious metals are strongly tied to monetary conditions. Finally, while the benefits of adding precious metals to an investment portfolio varied somewhat over time, they prevailed throughout much of the 34-year period. Overall, evidence suggests that investors could improve portfolio performance considerably by adding a significant exposure to the equities of precious metals firms.Other researches depicting relation between metals and stock returns (Baur & Lucey, 2010; Ciner, Gurdgiey, & Lucey, 2010; Coudert & Raymond, 2010; Hillier) have shown that returns in the metals and stock markets are negatively associated. Consequently, incorporating precious metals into stock-market investment portfolios can effectively reduce investment portfolio risk

Researches done by (Gorton & Rouwenhorst, 2006; Hunjra, Azam, Niazi, Butt, Rehman, & Azam, 2011; Jalil, Ghani, Daud, & Ibrahim, 2009; Park & Ratti, 2008; Summer, Johnson, & Soenen, 2010; Wang, Wang, & Huan, 2010) also supports that the returns on commodity futures are inversely related to returns in the stock and bond markets.

Literature on commodity as a Inflation hedge:

Another line of research (Greer, 1978; Bodie, 1983; Halpern and Warsager, 1998; and Becker and Finnerty, 2000) has noted that commodity price increases at times of unexpected growth in inflation (i.e., positive correlation), in comparison to the decreasing trend of stock prices and bond prices. In the same spirit, it has also been found that commercial and residential real estate provide at least a partial hedge against inflation, an effect that seems to be particularly significant over long-horizons (see Fama and Schwert (1977), Hartzell *et al.* (1987), Rubens *et al.* (1989). Georgiev (2001), analyzing the trend of three indexes linked to commodities between1920 and 2003, confirms the presence of diversification and inflation effects, especially in energy and precious metals sectors. Gorton and Rouwenhorst (2006) stated that commodity prices, in particular, have been found to be leading indicators of inflation in that they are quick to respond to economy wide shocks to demand.

Dieter et al.(2008) investigates the impact of seventeen US macroeconomic announcements on two broad and representative commodity futures indices. They found that news about higher (lower) inflation and real activity lead to positive (negative) adjustments of commodity futures prices.Chong & Miffre (2010) examines conditional correlations between various commodity futures with stock and fixed-income indices. Conditional correlations with equity returns fell over time, which indicates that commodity futures have become better tools for strategic asset allocation. The correlations between the S&P 500 Index and several commodities also fell in periods of above-average volatility in equity markets. Results also suggest that adding commodity futures to T-bill portfolios reduces risk further in volatile interest rate environments.Overall results of the studies suggest that contrary to equities investment in commodities provides a hedge against inflation.

Literature on commodity portfolio:

The Landmark study on portfolio diversification was done by Jensen, Johnson & Mercer, 1985 who examined the diversification benefits of adding managed and unmanaged commodity futures to a traditional portfolio that consists of U.S. equities, foreign equities, corporate bonds, and Treasury bills from 1973 through 1999. They found that commodity futures substantially enhance portfolio performance for investors with metals and agricultural futures contracts offering the most diversification benefits for investors. Satyanarayan & Varangis(1994) analyze the benefits of including commodity futures and assets from emerging markets in an investment portfolio and concluded that including commodity futures and assets from emerging markets in investment portfolios produces a significant risk/return benefit. Kaplan and Lummer(1998)considered the performance of two portfolios. The first consisted of 60% in US stocks, 30% in bonds and 10% in bills and a second portfolio consisting of 57% US stocks, 28.5% in bonds, 9.5% in bills and 5% in GCSI. Over the period 1970 to 19966, the first portfolio returned 11.1% per annum with a standard deviation of 11.8% whereas the second returned 11.4% with a standard deviation of 11%. Clearly the

second portfolio was more efficient. Abanomey & Mathur(1999) models the potential gains in the risk/return tradeoffs by including commodities futures into a portfolio of international stocks and bonds. The study provides significant positive results in favor of commodity futures. Becker and Finnerty (2000) stated, with reference to the period from 1970 to 1990, that the risk and return of a portfolio composed of stocks and bonds had increased with the inclusion of commodities in asset allocation. They specify that this increase had been more valid in the 1970s compared to the following decade, due to high inflation in the first part of the study period. Jensen *et al.* (2002) also examined the S&P GSCI and some of its sub indices, during the period,January 1973 to September 1999. The results confirm low correlation of commodities with other asset classes and the increase in performance is linked to the commodity futures contribution. One of the more important contributions to the literature is that of Gorton and Rouwenhorst (2005). They construct their own commodity futures index for the period 1959 – 2004 and examine how this compares with returns from stock and bond indices. They concluded that the average annualized return on the collateralized futures index was very similar to that on the SP500 over the whole period and both assets outperformed corporate bonds. They also found that the relative performance varied over time and that "the diversification benefits of commodities work well when they are needed most". Hence one conclusion reached was that commodity futures are useful in creating diversified portfolios with respect to the idiosyncratic component of returns"

Erb and Harvey (2006) pointed out that the S&P GSCI, during the period 1969-2004, had a compounded annual return (12.2%) better than that of the S&P 500 index (11.2%), and in terms. By further investigation of S&P GSCI, during period 1982-2004, they formed a portfolio composed of 12 commodities which are included in the S&P GSCI, and have been in the basket right from the beginning of the S&P GSCI. The results show that their portfolio obtained an extra annual compound return of 4.49%, in comparison to 3.45% of Lehman Aggregate Bond Indexand 7.35% of S&P 500 stock index. Recently, Gorton and Rouwenhorst (2006) disagreed with their results. In fact they opined that a long position in commodities futures produced a risk premium and in long-term this allocation was comparable to a stock long position. The authors, after having compared an equally weighted index of 34 commodities futures (between July 1959 and December 2004), have showed that this basket obtains returns equal to the benchmark stock at times of less risk. Ibbotson (2006) also examined the case for including commodity futures in portfolios. This study was based on annual data over the period 1970 to 2004 and found that "over the common standard deviation range, the average improvement in historical return at each of the risk levels was approximately 133 basis points". They also constructed a forward looking CAPM model and found that the average improvement at each of the risk levels was approximately 35 basis points. Erb and Harvey (2006),using data ranging mainly from 1982 to 2004, question the long-term benefits of allocating commodities to portfolios and instead attribute the benefits mainly to portfolio rebalancing. Cheung & Miu(2010) empirically tested the statistical significance of adding commodity futures to an existing portfolio

and concluded that the diversification benefit of commodities is a far more complex phenomenon than often understood in the finance literature. Smimou, K. (2010) examines international portfolio diversification by adding foreign agriculture future contracts to the bond and equity portfolio and found results in favor of international diversification of agricultural commodities.

You and Daigler (2013), examine the diversification benefits of using *individual* futures contracts instead of simply a commodity index. They determine the ex-ante, ex-post, and stability results for optimal Markowitz portfolios, investigate the instability between the ex-ante and ex-post results, and compare our results to traditional and naïve portfolios. The ex-ante complete futures portfolio dominates the traditional and naive portfolios and the ex-post portfolio outperforms the naïve portfolio. The instability between the ex-ante and ex-post results is primarily driven by the time-varying returns of the individual assets rather than by risk.

All the studies reviewed above in context of the diversification aspect of commodity futures were done in developed commodity markets typically US but in India Commodities market are still at a very nascent stage as compared to developed markets. Majority of the published research in India on commodity futures had focused on the issue of market efficiency by comparing volatility of the agricultural markets before and after the introduction of commodity futures. Some researchers also focused upon backwardation and contango markets but the risk diversification aspect of commodity futures relatively remains unaddressed. Therefore in this study an attempt has been made to evaluate whether addition of commodity futures to a typical bond or equity or bond/equity portfolio in emerging commodity market like India will provide same diversification benefit as in developed market.

Objectives of the study:

To explore whether adding commodity derivatives in an equity/bond portfolio would provide diversification benefit.

To explore whether adding commodity derivatives in an equity/bond portfolio would provide the portfolio a hedge against inflation risk.

To evaluate risk adjusted returns of different portfolios having different combination of commodity derivatives, bond and equity.

Sample and Data:

The study examines daily and monthly returns of three alternative asset classes for a data span of 8 years from Jan 2006 to Dec 2013.Since Commodity futures in India were introduced in 2003 and data was not available on the public domain from 2003 to 2006,therefore the study considers the sample from 2006 onwards. The main focus of this paper is on overall investment performance of these asset classes not the individual security/component of the asset class. Therefore for each investment asset class a composite index indicating the overall movement and performance of a particular investment asset has been considered.

Equity/Stock Returns: The study considers returns on SENSEX as a proxy for returns on equity investment.
Bond Returns: Wholesale debt markets return of NSE has been considered as a proxy for bond returns.
Commodity Indices: One of the most attractive aspects of commodity investment today is that there are now a number of passive indexes that are fully investible.Commodity indexes are a source of information on cash commodity and futures commodity market trends, are used as performance benchmarks for evaluation of commodity trading advisors, and provide a historical track record useful in developing asset allocation strategies. Commodity indices are generally based on the returns of futures contracts and/or cash markets.
Agriculture Returns: Multi Commodity Exchange Agriculture index has been considered as a proxy of agriculture sector returns.
Energy Returns: Multi Commodity Exchange Energy index has been considered as a proxy of energy sector returns.
Metal Returns: Multi Commodity Exchange Metal index has been considered as a proxy of metal sector returns.
Composite Commodity Returns: For composite commodity returns MCX COMDEX has been taken as a proxy. The MCX COMDEX is the simple weighted average of the three group indices - MCX AGRI, MCX METAL & MCX ENERGY. The group indices are computed based on Geometric Mean.

3. Methodology and Data Analysis

In order to evaluate diversification aspect of commodity futures, a correlation analysis of the daily rates of return of commodity futures contracts (Comdex. Energy, Metal and Agriculture) traded on MCX will be compared with the return on SENSEX and Bond. This will help in exploring whether commodities can be added to an equity/bond portfolio for the risk diversification.
Monthly returns of SENSEX, Bond, MCX Comdex, MCX Energy, MCX Metal and MCX Agri will also be compared with the monthly Inflation rate for the time frame of eight years from 2006 to 2013.

Standalone Risk and Return of Security:

Compounded Daily Growth rate of Indices have been calculated based on their daily prices for the eight years from 2006 to 2012.This CDGR has been considered as a measure of individual asset rate of return. It has been calculated as follows:
CDGR% = {[(Beginning Value/Ending Value)^(1/7*365)] -1}*100

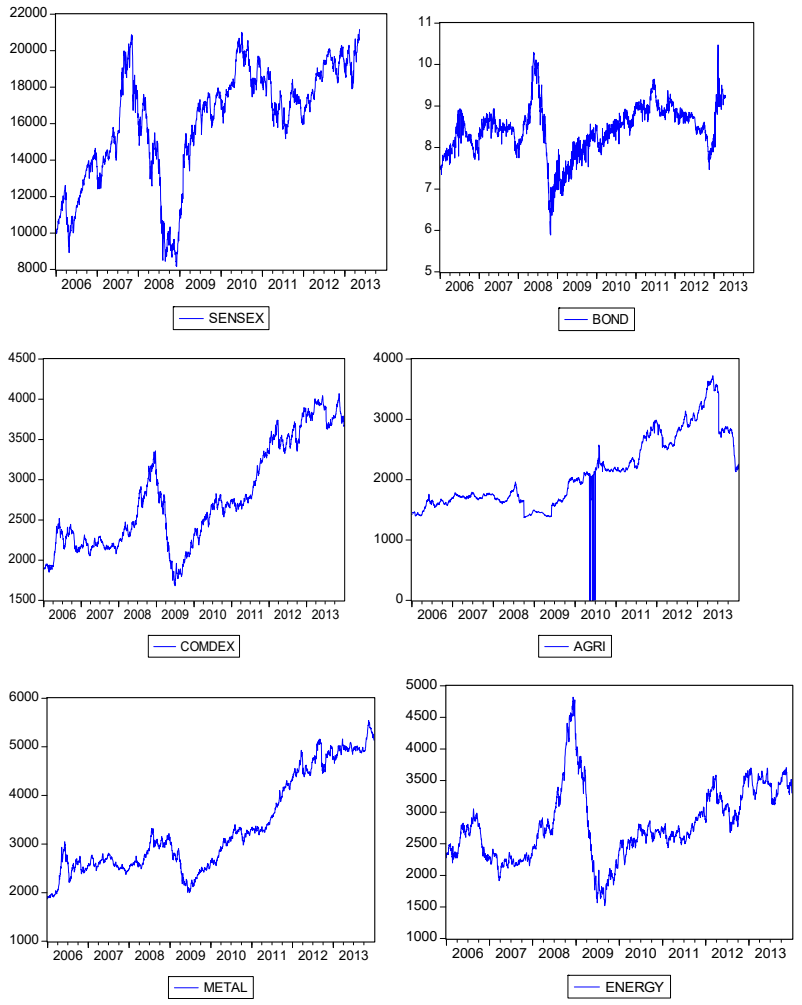
In order to calculate the risk of a Index in percentage terms based on daily data for a span of eight years, Relative standard deviation has been used. It has been calculated as follows:

RSD % = (Standard Deviation of daily prices/Mean of daily prices)*100
Portfolio Risk and Return has been calculated using Markowitz Portfolio theory.

Diversification benefit of commodity derivatives in an equity/bond portfolio:

Firstly let us have a look on the direction of movement of all the indices and other investment options from 2006 to 2013

Figure1: Daily data Plots of Individual Investment Asset

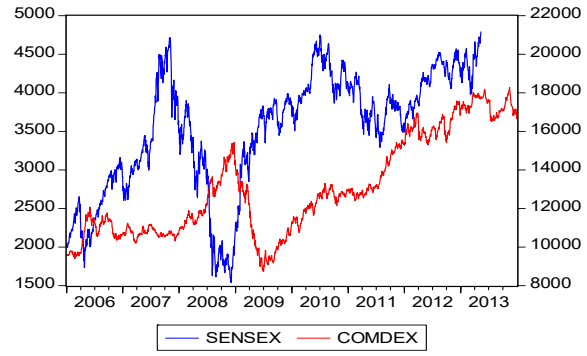


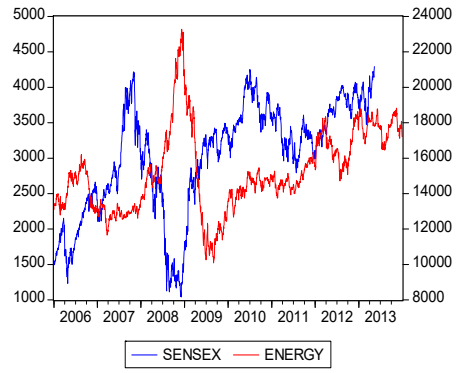
The first impression that is emerging from the graph of data sets is that the graph of agri and metal are showing a continuous upward trend whereas the graphs of all other investment assets depicts a prominent decline near 2008-09 and then recovery. In 2010 a sudden fall in the graph of MCX Agriculture was due to the fact that

government put a ban on the trading of future contracts of Agriculture in 2010.As soon as the ban was removed the trading regained its original path.

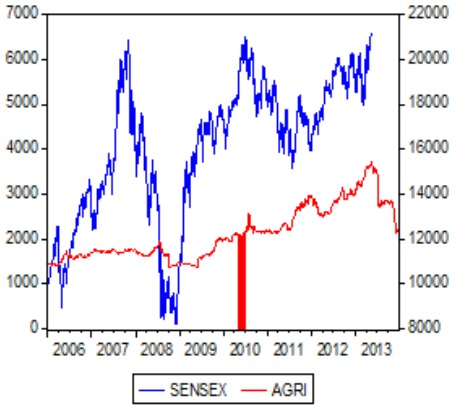
From the diversification aspect when the SENSEX was at decline and reached the bottom towards the end of 2008 MCX COMDEX was at its peak. When the SENSEX starts recovering in the beginning of 2009, MCX COMDEX starts declining. In a similar way when MCX Energy was rising when SENSEX was declining and vice versa. The Peaks of SENSEX are found to be more in contrast with peaks of MCX Energy as compared to COMDEX.

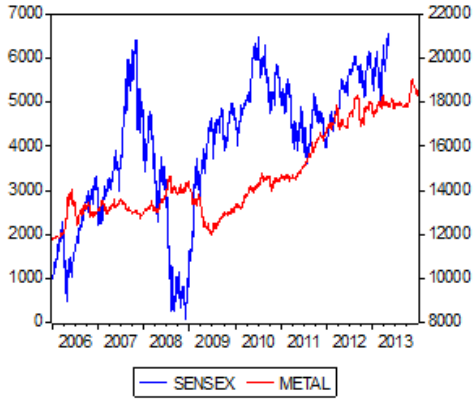
Figure 2: Plot of daily data of SENSEX versus Commodity Investment Asset





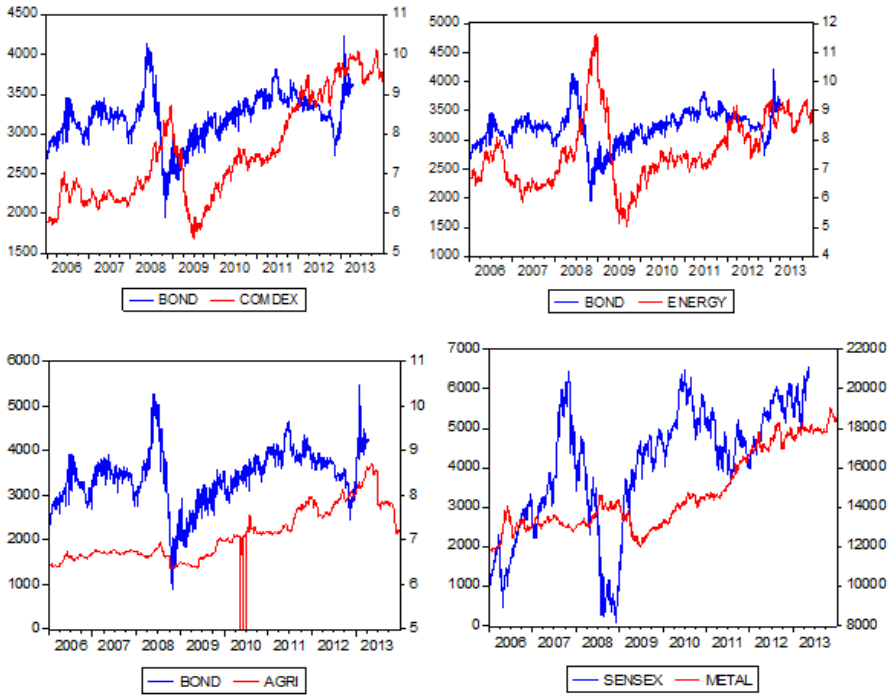
However the graphs of MCX Agriculture and MCX Metal were moving at their gradual upward moving phase. They are not showing any positive or negative movement with that of SENSEX.





In a similar way the graphs of all commodity indices has been plotted in context of movement of Bonds.

Figure 3: Plot of daily data of BOND versus Commodity Investment Asset



Visually the plots give an indication that the commodities, equity and bonds must have a negative or very low degree of correlation. However in order to get an confirmation regarding the same Correlation test has been applied and the results are presented in the table 1

Table:1 Correlation of Various Investment Assets

Correlation Coefficients of SENSEX and Bond with Commodity Indices		
	SENSEX	BOND
MCX COMDEX	0.014289	-0.018763
MCX Agriculture	0.010821	0.024657
MCX Energy	-0.012852	0.007862
MCX Metal	0.039178	-0.033231

Result of correlation analysis indicates that MCX Comdex has a very low degree of correlation of only one percent with SENSEX and it had a negative correlation with the bonds. In a similar way MCX Metal has 3% positive correlation with

SENSEX and 3% negative correlation with bond. On the Contrary MCX Energy has a negative correlation of 1% with SENSEX and had zero correlation with bonds.MCX Agriculture is found to have a positive correlation of 1% and 2% respectively with SENSEX and Bond. Overall all the commodity indices have a very low degree of positive or negative correlation with equity and bond. As Portfolio theory states that the portfolio must be allocated among securities having a very low correlation due to the fact that this will reduces the portfolio risk without decreasing the portfolio returns. Therefore we can say that commodities derivatives can be used as an alternative investment asset in context of equity/bond portfolio as they provide the diversification benefit to the investors.

Commodity derivatives as a hedge against inflation risk:

In order to check whether commodity derivatives provide a hedge against inflation year growth in inflation has been plotted against commodity indices, equity and bond.

Figure 4: Plot of Yearly increase in Inflation versus Different Investment Asset

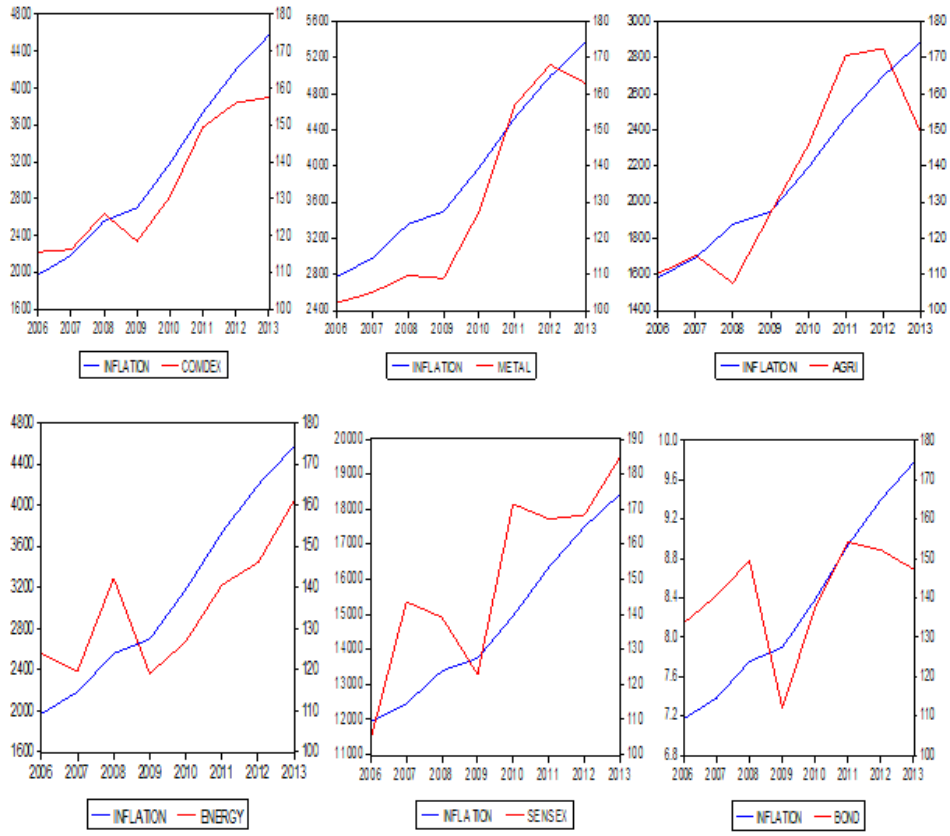


Table 2: Correlation of Monthly returns of various investment alternatives with Inflation

	BOND_YIELD	M_AGRI	M_COMDEX	M_ENERGY	M_METAL	SENSEX
INFLATION	0.250811	0.079003	0.464243	0.507562	0.275152	-0.04655

The correlation coefficients indicate that SENSEX is having a negative correlation with inflation which implies that as the inflation moves up the returns on SENSEX start declining. Commodity derivatives are having a significant positive correlation with the Inflation which implies that as the inflation moves up the return on these indices will also rise. This positive correlation further indicates that commodity derivatives can be used as a hedge against inflation

Commodity derivatives in a Portfolio:

Before looking at the risk return aspects of commodity derivatives in a portfolio aspect let us look at the average risk and return of individual investment option.

Table 3: Average Return and Risk of various Investment Alternatives

	SENSEX	BOND	MCX COMDEX	MCX Agriculture	MCX Metal	MCX Energy
Return %	12.31	3.00	11.37	8.81	15.11	8.55
Risk %	20.01	7.31	24.25	26.38	30.32	22.74

The results of the average return and volatility of various indices on standalone basis demonstrates some interesting results. As Expected bond reveals the lowest risk and return combination. The risk of all the commodity indices are higher than that of the risk of SENSEX with MCX Metal showing the highest risk at 30%.However the return of all the commodity indices are lower than that of SENSEX except for MCX Metal which provides higher return than SENSEX. Out of all the commodity Indices MCX Agri is the worst performer having higher volatility with the lowest return.MCX Metal demonstrates highest risk with highest return while SENSEX demonstrates higher return with moderate risk.

Next we will check the performance of commodity future indices when considered in the portfolio context. Portfolios were created broadly into three categories: Equity & commodity, Bond & Commodity and Equity, Bond & commodity combined together. They were started with pure equity/bond portfolio to a combination having different proportion of equity and commodity index and ended with pure commodity index portfolio. Proportion of weights in equity and commodity has been taken sequentially in decreasing order of bond/equity or increasing order of commodity index so as to avoid any biases. As bond gives the lowest returns but has low risk also therefore in order to provide the downward side risk protection their proportion has

been kept fixed at 10% in case of the combination of Equity, Bond and SENSEX portfolio. Risk and return of the portfolio has been calculated as per Modern Portfolio Theory.

Once the portfolio has been created another important task is to evaluate the performance of different portfolio and identify a optimal portfolio which will suggest us how much proportion one should invest in a particular asset. Sharpe ratio which is also known as risk adjusted volatility ratio has been used to evaluate the portfolios.

Table 4: Analysis of the SENSEX and MCX COMDEX Portfolios

Portfolio	SENSEX	MCX COMDEX	RT MCX COMDEX	C Risk	Sharpe Ratio
A	1	0	12.31027	20.01394	0.365259
B	0.95	0.05	12.263417	19.06917	0.380898
C	0.9	0.1	12.216563	18.20946	0.396309
D	0.85	0.15	12.16971	17.44738	0.410933
E	0.8	0.2	12.122856	16.79624	0.424074
F	0.75	0.25	12.076003	16.26936	0.434928
G	0.7	0.3	12.029149	15.87911	0.442667
H	0.65	0.35	11.982296	15.63572	0.446561
I	0.6	0.4	11.935442	15.5461	0.446121
J	0.55	0.45	11.888589	15.61289	0.441212
K	0.5	0.5	11.841735	15.83412	0.432088
L	0.45	0.55	11.794882	16.20346	0.419348
M	0.4	0.6	11.748028	16.71109	0.403805
N	0.35	0.65	11.701175	17.34487	0.386349
O	0.3	0.7	11.654321	18.09156	0.367814
P	0.25	0.75	11.607468	18.93779	0.348904
Q	0.2	0.8	11.560614	19.87087	0.330162
R	0.15	0.85	11.513761	20.87914	0.311975
S	0.1	0.9	11.466907	21.95225	0.29459
T	0.05	0.95	11.420054	23.08116	0.278151
U	0	1	11.3732	24.25807	0.262725

Figure 5: Efficient frontier of the SENSEX and MCX COMDEX Portfolios

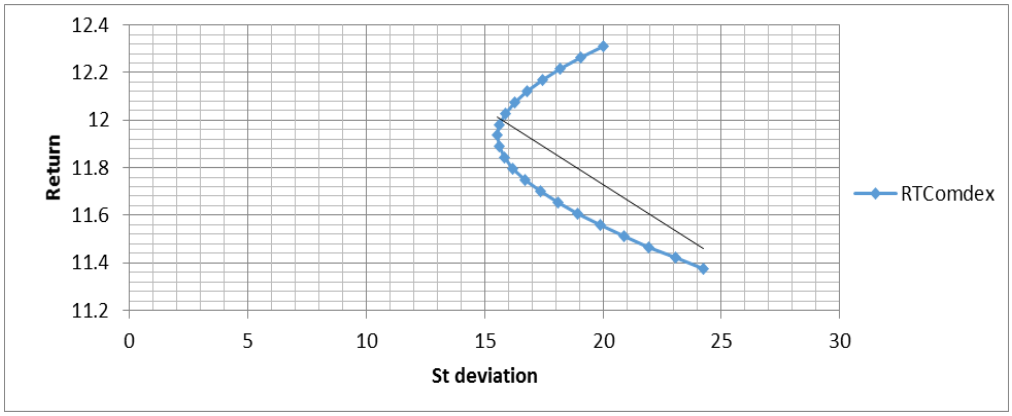


Table 5: Analysis of the SENSEX and MCX Agriculture Portfolios

Portfolio	SENSEX	MCX Agri	RT MCX Agri	A Risk	Sharpe Ratio
A	1	0	12.31027	20.01394	0.365259
B	0.95	0.05	12.13542	19.07319	0.374107
C	0.9	0.1	11.96058	18.233	0.381757
D	0.85	0.15	11.78573	17.50784	0.387583
E	0.8	0.2	11.61089	16.91251	0.390887
F	0.75	0.25	11.43604	16.46111	0.390985
G	0.7	0.3	11.2612	16.1657	0.387314
H	0.65	0.35	11.08635	16.03491	0.379569
I	0.6	0.4	10.91151	16.07274	0.367797
J	0.55	0.45	10.73666	16.27804	0.352417
K	0.5	0.5	10.56181	16.6446	0.334151
L	0.45	0.55	10.38697	17.16209	0.313888
M	0.4	0.6	10.21212	17.81736	0.292531
N	0.35	0.65	10.03728	18.59586	0.270882
O	0.3	0.7	9.862432	19.48282	0.249575
P	0.25	0.75	9.687587	20.46415	0.229063
Q	0.2	0.8	9.512741	21.52693	0.209632
R	0.15	0.85	9.337896	22.65971	0.191436
S	0.1	0.9	9.16305	23.85253	0.174533
T	0.05	0.95	8.988205	25.09682	0.158913
U	0	1	8.813359	26.3853	0.144526

Figure 6: Efficient frontier of the SENSEX and MCX Agriculture Portfolios

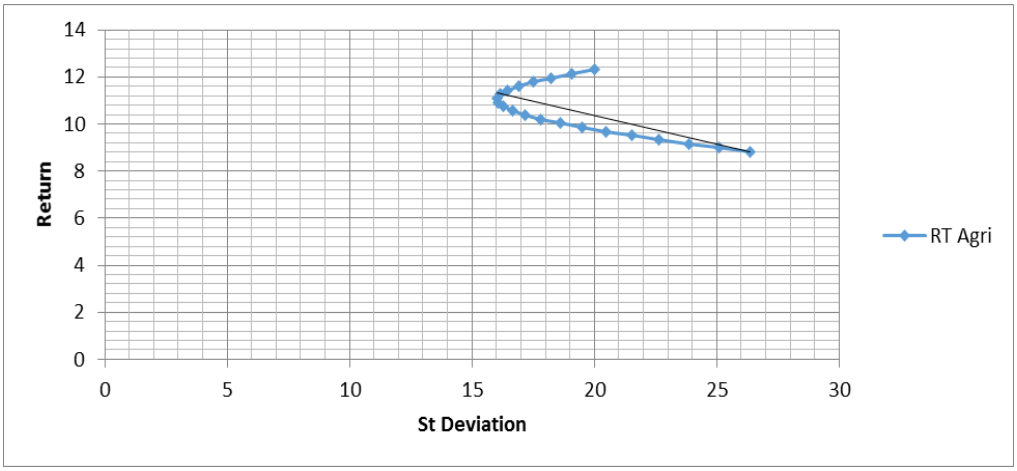


Table 6: Analysis of the SENSEX and MCX Metal Portfolios

Portfolio	SENSEX	MCX Metal	RT MCX Metal	M Risk	Sharpe Ratio
A	1	0	12.31027	20.01394	0.365259
B	0.95	0.05	12.45038	19.13275	0.389404
C	0.9	0.1	12.59049	18.3829	0.41291
D	0.85	0.15	12.7306	17.781	0.434767
E	0.8	0.2	12.8707	17.34248	0.45384
F	0.75	0.25	13.01081	17.0799	0.46902
G	0.7	0.3	13.15092	17.00144	0.479425
H	0.65	0.35	13.29103	17.10962	0.484583
I	0.6	0.4	13.43114	17.40097	0.484521
J	0.55	0.45	13.57125	17.86651	0.479738
K	0.5	0.5	13.71136	18.49312	0.471059
L	0.45	0.55	13.85146	19.26506	0.459457
M	0.4	0.6	13.99157	20.16567	0.445885
N	0.35	0.65	14.13168	21.17853	0.431176
O	0.3	0.7	14.27179	22.28834	0.415993
P	0.25	0.75	14.4119	23.48137	0.400824
Q	0.2	0.8	14.55201	24.74557	0.386009
R	0.15	0.85	14.69211	26.0706	0.371764
S	0.1	0.9	14.83222	27.44765	0.358217
T	0.05	0.95	14.97233	28.86928	0.345431
U	0	1	15.11244	30.32921	0.333422

Figure 7: Efficient frontier of the SENSEX and MCX Metal Portfolios

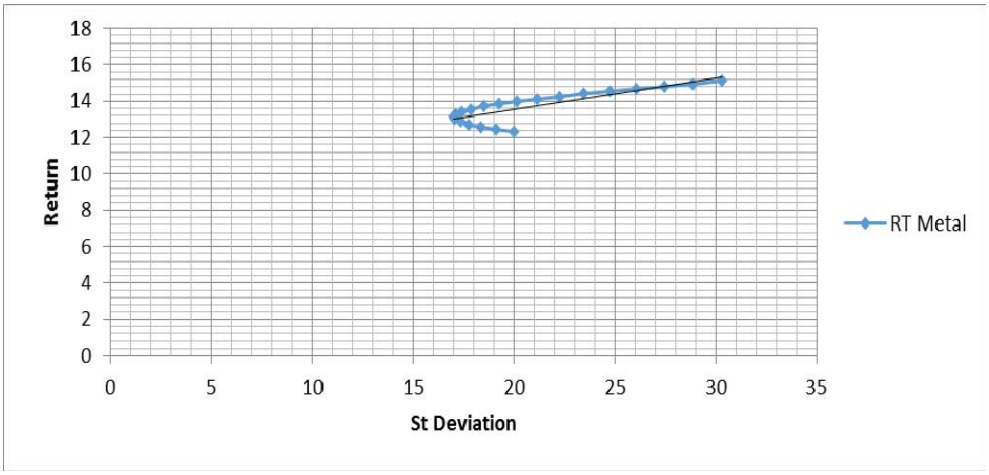
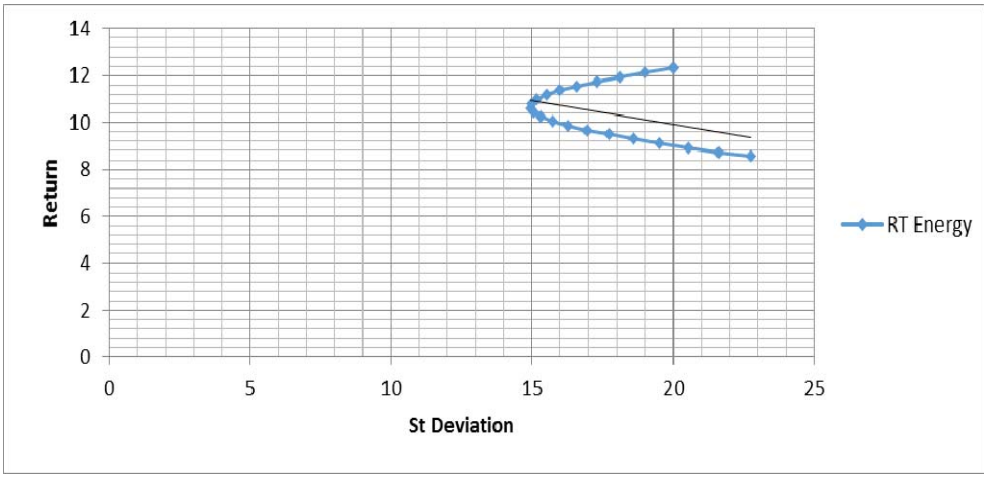


Table 7: Analysis of the SENSEX and MCX Energy Portfolios

Portfolio	SENSEX	MCX Energy	RT MCX Energy	E Risk	Sharpe Ratio
A	1	0	12.31027	20.01394	0.365259
B	0.95	0.05	12.12251	19.03263	0.374226
C	0.9	0.1	11.93475	18.12656	0.382574
D	0.85	0.15	11.74699	17.30755	0.389829
E	0.8	0.2	11.55923	16.5885	0.395408
F	0.75	0.25	11.37146	15.9829	0.398642
G	0.7	0.3	11.1837	15.50407	0.398844
H	0.65	0.35	10.99594	15.164	0.395406
I	0.6	0.4	10.80818	14.97216	0.387932
J	0.55	0.45	10.62042	14.93427	0.376344
K	0.5	0.5	10.43266	15.05147	0.360939
L	0.45	0.55	10.2449	15.32023	0.342351
M	0.4	0.6	10.05714	15.73276	0.32144
N	0.35	0.65	9.869374	16.27815	0.299136
O	0.3	0.7	9.681613	16.94357	0.276306
P	0.25	0.75	9.493851	17.71549	0.253668
Q	0.2	0.8	9.30609	18.58066	0.231751
R	0.15	0.85	9.118329	19.52667	0.210908
S	0.1	0.9	8.930568	20.54237	0.19134
T	0.05	0.95	8.742806	21.61793	0.173134
U	0	1	8.555045	22.74486	0.156301

Figure 8: Efficient frontier of the SENSEX and MCX Energy Portfolios



Result of the SENSEX & MCX COMDEX Portfolio

The analysis above reveals that the portfolio A with pure equity had a risk and return of 20% and 12% respectively. The risk of pure COMDEX portfolio U is higher than that of pure equity portfolio. Moving towards combination of equity and commodity from portfolio B as the proportion of high risky COMDEX in the portfolio is increased from 0% to 5% the overall risk of the portfolio declines from 20% to 19% and the risk adjusted return ratio increases from 36% to 38%.This indicates that although COMDEX on a standalone basis is risky but when considered in combination with equity it actually decreases the risk and improves the risk adjusted return ratio. This will continue till the optimal portfolio having that optimum proportion of SENSEX and COMDEX, which will have the highest risk adjusted return ratio is reached. The above combination indicates that portfolio H is the optimal portfolio having highest risk adjusted return ratio. It also demonstrates that the SENSEX and COMDEX must be combined together in the proportion of 65% and 35% respectively. Beyond this if the proportion of COMDEX in the portfolio will increase it will increase the risk of the portfolio while decreasing returns.

When the risk and return combination of different portfolios have been plotted the line depicting the combination is known as efficient frontier. On efficient frontier the portfolio having the lowest risk is known as global minimum variance portfolio. Here Portfolio I is the global minimum variance portfolio. On the efficient Frontier the point where the straight line touches is the point where optimal portfolio lies. In this case as the straight line touches the portfolio H so portfolio H is the optimal portfolio.

Result of the SENSEX & MCX Agriculture Portfolio

In case of Portfolio having combination of SENSEX and MCX Agri, the standalone risk of pure commodity portfolio was higher by 6% and the return was lower

by 4% as compared to pure equity portfolio. However when the commodity was combined along with pure equity the interactive risk of the portfolio declines by 1%.The risk adjusted return ratio also improves. This demonstrates that by combining MCX Agri which is otherwise more risky to a pure SENSEX portfolio the risk of portfolio declines while the return of the portfolio will be enhanced. Now the proportion in which Agricultural commodity and equity should be combines is revealed by optimal portfolio having highest risk adjusted return ratio. In this case portfolio F is the optimal portfolio having highest Sharpe ratio of 39%.This suggests that the maximum returns will be obtained when the MCX Agri and SENSEX were combined in the ratio of 25% and 75% respectively.

The efficient frontier has been obtained by plotting risk return combination of different portfolios. The straight line touches the curve at point F indicating that the portfolio F is the optimal portfolio and Portfolio H is the global minimum variance portfolio.

Result of the SENSEX & MCX Energy Portfolio

The risk of pure Energy portfolio U is higher and return is lower than that of pure equity portfolio A. Moving towards combination of equity and commodity from portfolio B as the proportion of high risky MCX Energy in the portfolio is increased from 0% to 5% the overall risk of the portfolio declines from 20% to 19% and the risk adjusted return ratio increases from 36% to 37%.This indicates that although MCX Energy on a standalone basis is high risky with low returns but when considered in combination with equity the interactive risk actually decreases and the risk adjusted return ratio increased. The above combination also indicates that portfolio G is the optimal portfolio having highest risk adjusted return ratio of 39%. It also demonstrates that the SENSEX and MCX Energy must be combined together in the proportion of 70% and 30% respectively. Beyond this if the proportion of commodity in the portfolio will increase it will increase the risk of the portfolio while decreasing returns.

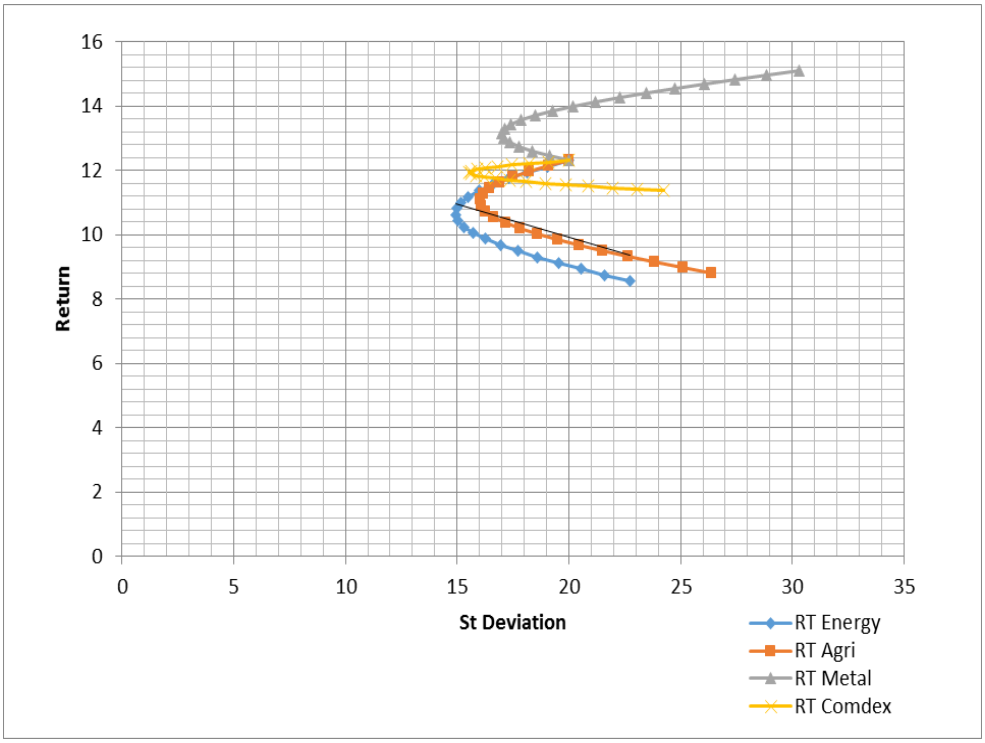
When the risk and return combination of different portfolios have been plotted efficient frontier is obtained. Here Portfolio J is the global minimum variance portfolio and portfolio G is the optimal portfolio.

Result of the SENSEX & MCX Metal Portfolio

In case of Portfolio having combination of SENSEX and MCX Metal, the risk and return of pure commodity portfolio is higher as compared to pure equity portfolio. However when the commodity was combined along with pure equity the interactive risk of the portfolio declines by 1%.The risk adjusted return ratio also improves. This demonstrates that by combining MCX Metal which is otherwise more risky to a pure SENSEX portfolio the risk of portfolio declines while the return of the portfolio will be enhanced. The result above also indicates that Portfolio H is the optimal portfolio having highest Sharpe ratio of 48% .This optimal portfolio indicates the proportion in

which commodity and equity should be combined In this case the MCX Energy and SENSEX should be combined in the ratio of 35% and 65% respectively.
The efficient frontier has been obtained by plotting risk return combination of different portfolios. The straight line touches the curve at point H indicating that the portfolio F is the optimal portfolio.
Now the combined efficient frontier of all the four commodity indices in combination with SENSEX has been plotted.

Figure 9: Combined Efficient frontier of SENSEX and Commodity Indices



Result of Combined Efficient Frontiers:

The result of combined efficient frontier depicts that out of the four commodity indices in combination with SENSEX, MCX Energy provides the maximum downward side risk protection having the minimum risk of 14.93. The highest risk was possessed by MCX Metal. In a similar way out of the four commodity indices in combination with SENSEX, the highest risk adjusted was provided by MCX Metal. If we compare MCX AGRI and MCX Energy then at the similar level of risk the return of MCX AGRI is higher as compared to MCX Energy. This suggests that an investor who is risk averse and whose preference is risk protection will prefer to invest in combination of SENSEX & MCX Energy whereas an investor who gets utility by taking more risk for more

returns will prefer to invest in combination of SENSEX & MCX Metal. Investor having inclination towards moderate risk return would tend to invest in MCX AGRI.
In a similar way to equity now the portfolios having different combinations of BOND and Commodity have been created and evaluated to identify the best combination.

Table 9: Analysis of the BOND and MCX COMDEX Portfolios

Portfolio	BOND	MCX Comdex	CRisk	RT MCX Comdex	Sharpe ratio
A	1	0	7.315659	3.009361	-0.27211
B	0.95	0.05	7.032499	3.42755295	-0.2236
C	0.9	0.1	6.973946	3.8457449	-0.16551
D	0.85	0.15	7.145556	4.26393685	-0.10301
E	0.8	0.2	7.531612	4.6821288	-0.0422
F	0.75	0.25	8.101514	5.10032075	0.012383
G	0.7	0.3	8.819697	5.5185127	0.05879
H	0.65	0.35	9.65312	5.93670465	0.097036
I	0.6	0.4	10.57457	6.3548966	0.128128
J	0.55	0.45	11.56303	6.77308855	0.153341
K	0.5	0.5	12.60273	7.1912805	0.173874
L	0.45	0.55	13.682	7.60947245	0.190723
M	0.4	0.6	14.79218	8.0276644	0.20468
N	0.35	0.65	15.92681	8.44585635	0.216356
O	0.3	0.7	17.08101	8.8640483	0.226219
P	0.25	0.75	18.25108	9.28224025	0.234629
Q	0.2	0.8	19.43414	9.7004322	0.241865
R	0.15	0.85	20.62797	10.1186242	0.24814
S	0.1	0.9	21.8308	10.5368161	0.253624
T	0.05	0.95	23.04121	10.9550081	0.25845
U	0	1	24.25807	11.3732	0.262725

Figure 10: Efficient frontier of the BOND and COMDEX Portfolios

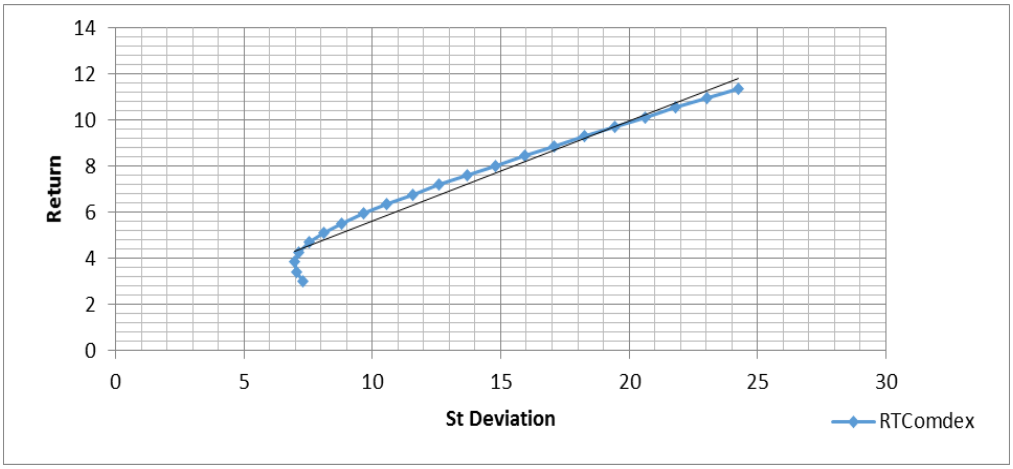


Table 10: Analysis of the BOND and MCX Agriculture Portfolios

Portfolio	BOND	MCX Agri	ARisk	RT MCX Agri	Sharpe ratio
A	1	0	7.315658	3.009361	-0.27211
B	0.95	0.05	7.105869	3.299561	-0.2393
C	0.9	0.1	7.153238	3.589761	-0.19715
D	0.85	0.15	7.452863	3.879961	-0.15028
E	0.8	0.2	7.976368	4.170161	-0.10404
F	0.75	0.25	8.683355	4.460361	-0.06215
G	0.7	0.3	9.533088	4.75056	-0.02617
H	0.65	0.35	10.49094	5.04076	0.003885
I	0.6	0.4	11.52999	5.33096	0.028704
J	0.55	0.45	12.63023	5.62116	0.04918
K	0.5	0.5	13.77699	5.91136	0.066151
L	0.45	0.55	14.95958	6.20156	0.08032
M	0.4	0.6	16.17015	6.49176	0.092254
N	0.35	0.65	17.40286	6.78196	0.102395
O	0.3	0.7	18.65331	7.07216	0.111088
P	0.25	0.75	19.91816	7.36236	0.118603
Q	0.2	0.8	21.19485	7.652559	0.125151
R	0.15	0.85	22.48134	7.942759	0.130898
S	0.1	0.9	23.77606	8.232959	0.135975
T	0.05	0.95	25.07772	8.523159	0.14049
U	0	1	26.3853	8.813359	0.144526

Figure 11: Efficient frontier of the BOND and MCX Agriculture Portfolios

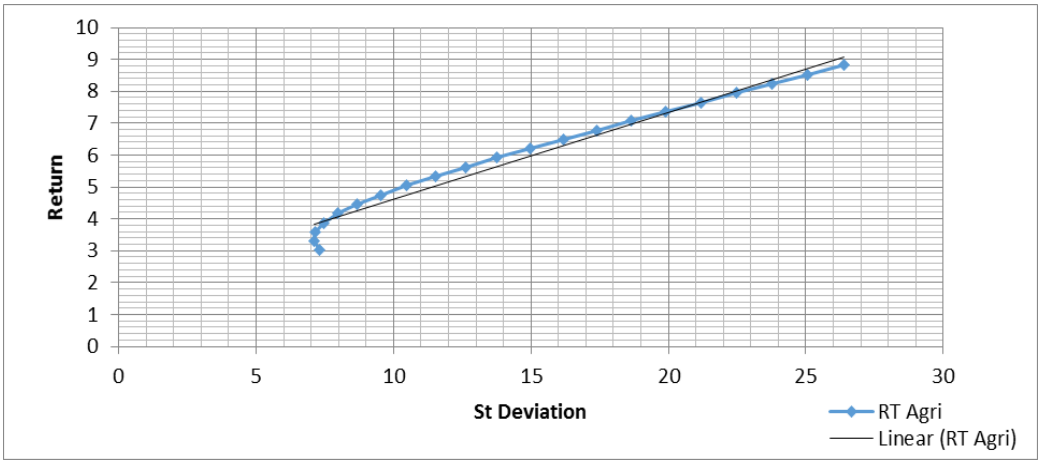


Table 11: Analysis of the BOND and MCX Energy Portfolios

Portfolio	BOND	MCX Energy	E Risk	RT MCX Energy	Sharpe ratio
A	1	0	7.315658	3.009361	-0.27211
B	0.95	0.05	7.051125	3.286645	-0.24299
C	0.9	0.1	6.982767	3.563929	-0.20566
D	0.85	0.15	7.116239	3.841214	-0.16284
E	0.8	0.2	7.440688	4.118498	-0.11847
F	0.75	0.25	7.932715	4.395782	-0.07617
G	0.7	0.3	8.563484	4.673066	-0.03818
H	0.65	0.35	9.304821	4.95035	-0.00534
I	0.6	0.4	10.13249	5.227635	0.022466
J	0.55	0.45	11.02706	5.504919	0.045789
K	0.5	0.5	11.97355	5.782203	0.065328
L	0.45	0.55	12.9606	6.059487	0.081747
M	0.4	0.6	13.9796	6.336771	0.095623
N	0.35	0.65	15.02407	6.614056	0.107431
O	0.3	0.7	16.08904	6.89134	0.117555
P	0.25	0.75	17.1707	7.168624	0.126298
Q	0.2	0.8	18.26608	7.445908	0.133904
R	0.15	0.85	19.37286	7.723192	0.140567
S	0.1	0.9	20.48919	8.000477	0.146442
T	0.05	0.95	21.61359	8.277761	0.151653
U	0	1	22.74486	8.555045	0.156301

Figure 12: Efficient frontier of the BOND and MCX Energy Portfolios

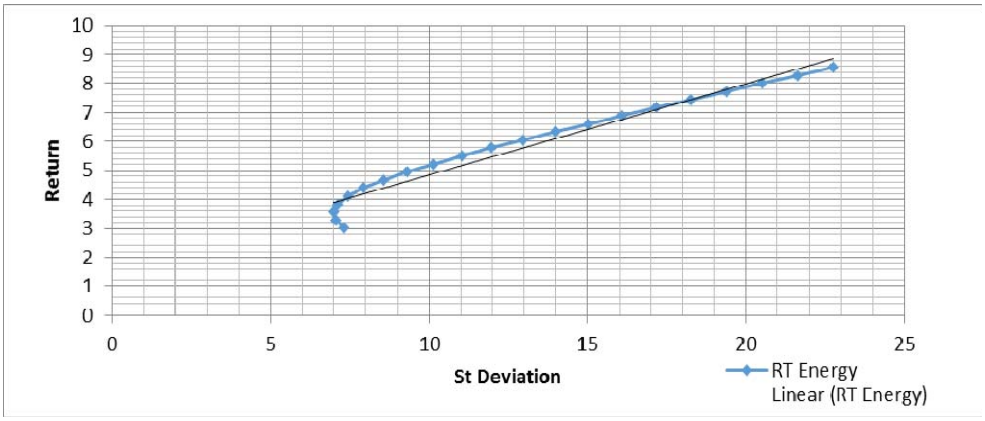
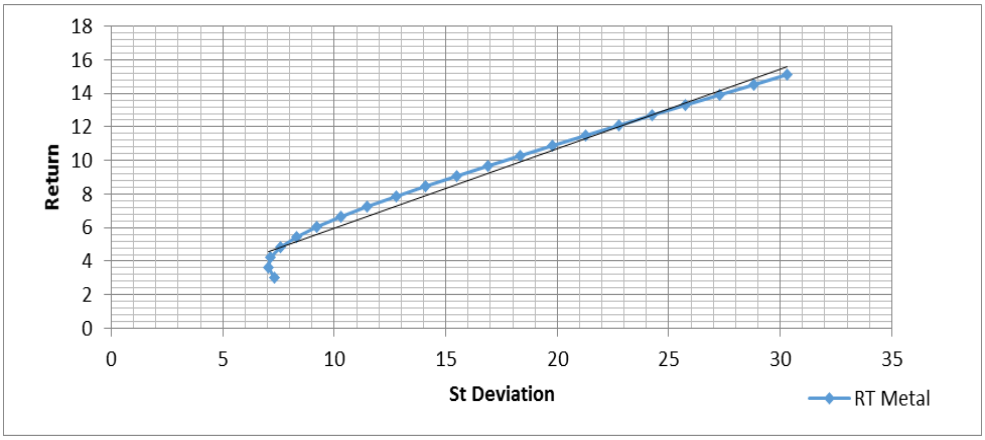


Table 12: Analysis of the BOND and MCX Metal Portfolios

Portfolio	BOND	MCX Metal	M Risk	RT MCX Metal	Sharpe ratio
A	1	0	7.315658	3.009361	-0.27211
B	0.95	0.05	7.063992	3.614515	-0.19613
C	0.9	0.1	7.156936	4.219669	-0.10903
D	0.85	0.15	7.581829	4.824823	-0.0231
E	0.8	0.2	8.287771	5.429977	0.051881
F	0.75	0.25	9.210363	6.035131	0.112388
G	0.7	0.3	10.2915	6.640285	0.159382
H	0.65	0.35	11.48651	7.245439	0.195485
I	0.6	0.4	12.76344	7.850593	0.22334
J	0.55	0.45	14.10006	8.455747	0.245087
K	0.5	0.5	15.48091	9.060901	0.262317
L	0.45	0.55	16.89514	9.666054	0.276177
M	0.4	0.6	18.33505	10.27121	0.287494
N	0.35	0.65	19.79501	10.87636	0.296861
O	0.3	0.7	21.27092	11.48152	0.304713
P	0.25	0.75	22.75965	12.08667	0.31137
Q	0.2	0.8	24.25886	12.69182	0.317073
R	0.15	0.85	25.76672	13.29698	0.322004
S	0.1	0.9	27.28178	13.90213	0.326303
T	0.05	0.95	28.80291	14.50729	0.330081
U	0	1	30.32921	15.11244	0.333422

Figure 13: Efficient frontier of the BOND and MCX Metal Portfolios



Result Discussion:

The result of Commodity Indices in combination of Bonds provides some striking evidence. The return of a pure bond portfolio was even less than the risk free rate of return due to which the risk adjusted return ratio was negative for the pure bond portfolio. Now as the proportion of commodity was added to the pure bond portfolio the return of the portfolio starts to improve and the risk adjusted ratio started to increase. For the entire four commodity Indices the ratio was negative initially but with the increasing proportion of commodity it gradually becomes positive. But quite surprisingly the ratio continue to increase upto pure commodity portfolio and a optimal combination has not been arrived in case of the bond and commodity combination. The same results were obtained for all the four commodity indices and hence optimal portfolio with the combination of bond and commodity has not been found empirically in the present dataset.

Figure 14: Combined Efficient frontier of BOND and Commodity Indices

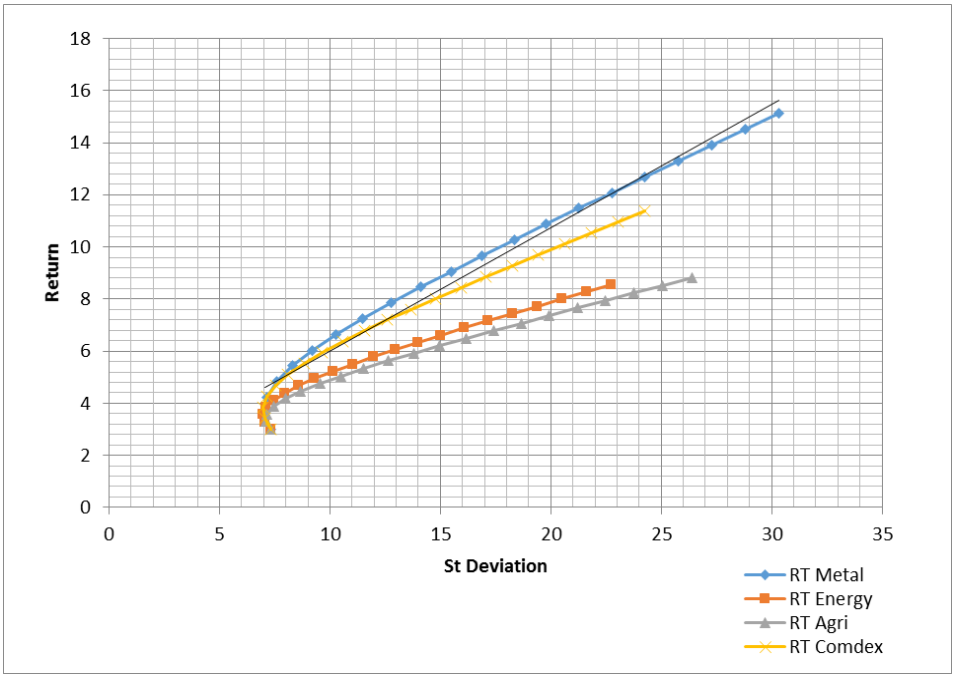


Table 13: Analysis of the SENSEX, BOND and COMDEX Portfolios

Portfolio	SENSEX	BOND	MCX Comdex	C Risk	C Return	Sharpe Ratio
A	0.8	0.1	0.1	16.23172	11.28647	0.387295
B	0.75	0.1	0.15	15.49906	11.23962	0.40258
C	0.7	0.1	0.2	14.89458	11.19277	0.415773
D	0.65	0.1	0.25	14.4344	11.14591	0.425782
E	0.6	0.1	0.3	14.13262	11.09906	0.431559
F	0.55	0.1	0.35	13.99949	11.0522	0.432316
G	0.5	0.1	0.4	14.03981	11.00535	0.427737
H	0.45	0.1	0.45	14.2521	10.9585	0.418078
I	0.4	0.1	0.5	14.62888	10.91164	0.404108
J	0.35	0.1	0.55	15.15789	10.86479	0.386913
K	0.3	0.1	0.6	15.82387	10.81794	0.367668
L	0.25	0.1	0.65	16.61035	10.77108	0.347439
M	0.2	0.1	0.7	17.5011	10.72423	0.327078
N	0.15	0.1	0.75	18.48104	10.67738	0.3072
O	0.1	0.1	0.8	19.53675	10.63052	0.288202

Figure 15: Efficient frontier of the SENSEX, BOND and COMDEX Portfolios

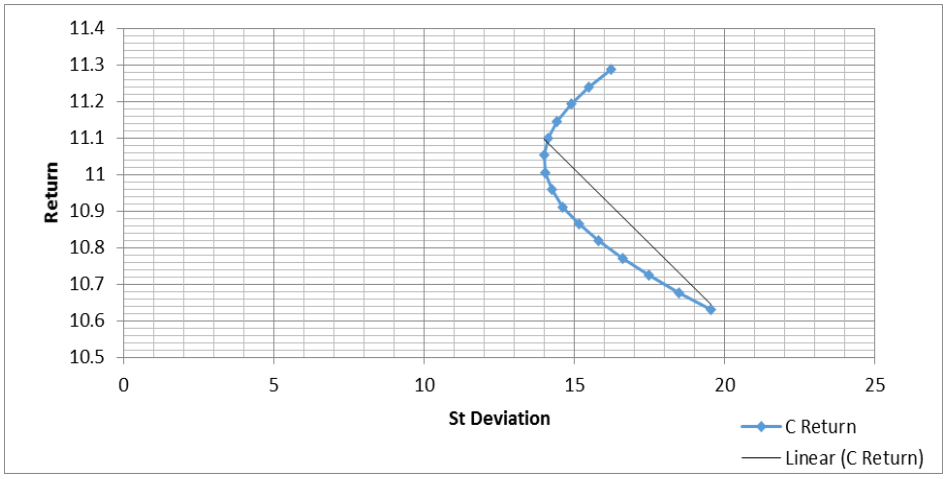


Table 14: Analysis of the SENSEX, BOND and MCX Agriculture Portfolios

Portfolio	SENSEX	BOND	MCX Agri	A Risk	A Return	Sharpe Ratio
A	0.8	0.1	0.1	16.26383	11.03049	0.370791
B	0.75	0.1	0.15	15.57602	10.85564	0.37594
C	0.7	0.1	0.2	15.03792	10.6808	0.377765
D	0.65	0.1	0.25	14.66602	10.50595	0.375422
E	0.6	0.1	0.3	14.47314	10.33111	0.368345
F	0.55	0.1	0.35	14.46645	10.15626	0.356429
G	0.5	0.1	0.4	14.6462	9.981415	0.340117
H	0.45	0.1	0.45	15.00568	9.806569	0.320317
I	0.4	0.1	0.5	15.53243	9.631724	0.298197
J	0.35	0.1	0.55	16.21015	9.456878	0.274944
K	0.3	0.1	0.6	17.02082	9.282033	0.251576
L	0.25	0.1	0.65	17.94642	9.107187	0.228858
M	0.2	0.1	0.7	18.97014	8.932341	0.207291
N	0.15	0.1	0.75	20.07698	8.757496	0.187154
O	0.1	0.1	0.8	21.25395	8.58265	0.168564

Figure 16: Efficient frontier of the SENSEX, BOND and MCX Agriculture Portfolios

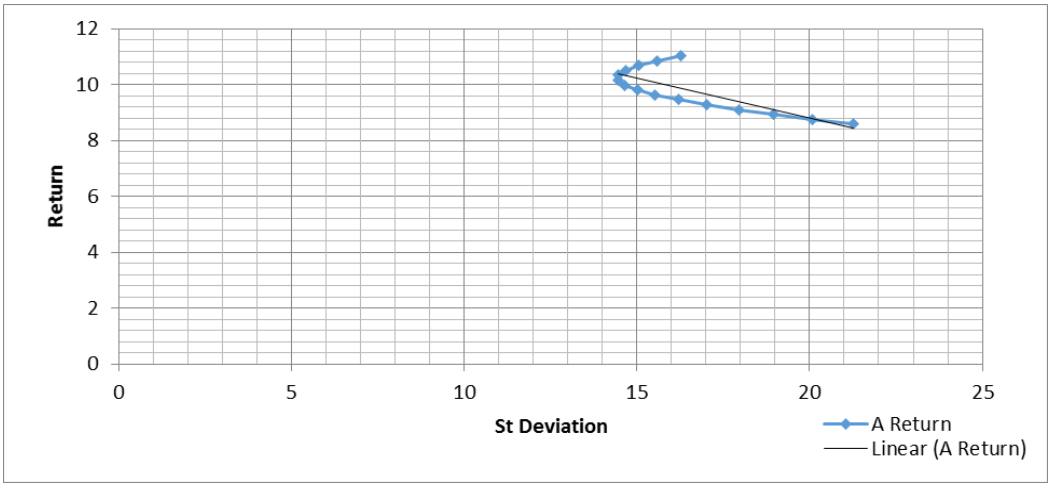


Table 15: Analysis of the SENSEX, BOND and MCX Energy Portfolios

Portfolio	SENSEX	BOND	MCX Energy	E Risk	E Return	Sharpe Ratio
A	0.8	0.1	0.1	16.14944	11.00466	0.371818
B	0.75	0.1	0.15	15.35847	10.8169	0.378742
C	0.7	0.1	0.2	14.68362	10.62913	0.383361
D	0.65	0.1	0.25	14.14153	10.44137	0.38478
E	0.6	0.1	0.3	13.7479	10.25361	0.382139
F	0.55	0.1	0.35	13.51572	10.06585	0.374812
G	0.5	0.1	0.4	13.45335	9.878089	0.362593
H	0.45	0.1	0.45	13.56312	9.690328	0.345815
I	0.4	0.1	0.5	13.84095	9.502567	0.325308
J	0.35	0.1	0.55	14.27703	9.314805	0.30222
K	0.3	0.1	0.6	14.85743	9.127044	0.277776
L	0.25	0.1	0.65	15.56601	8.939283	0.25307
M	0.2	0.1	0.7	16.38615	8.751522	0.228945
N	0.15	0.1	0.75	17.302	8.56376	0.205974
O	0.1	0.1	0.8	18.2992	8.375999	0.184489

Figure 17: Efficient frontier of the SENSEX, BOND and MCX Energy Portfolios

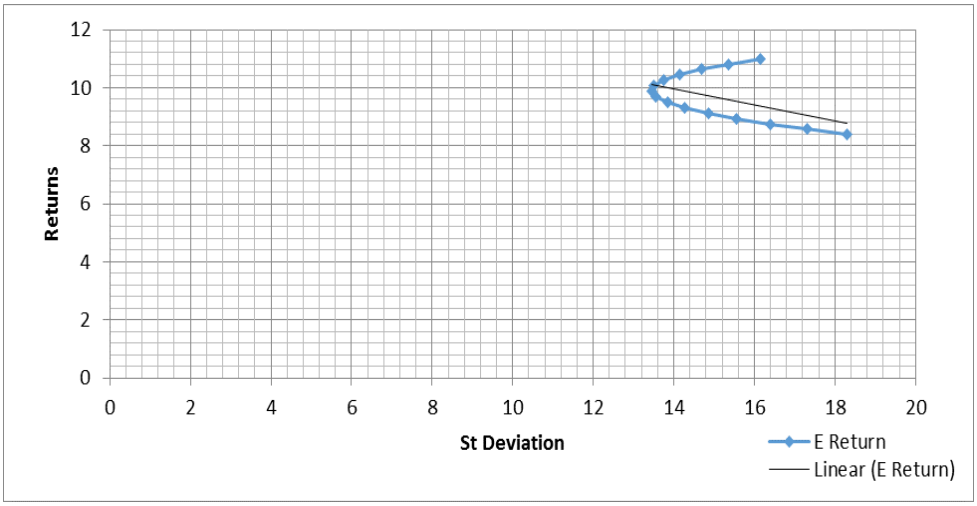
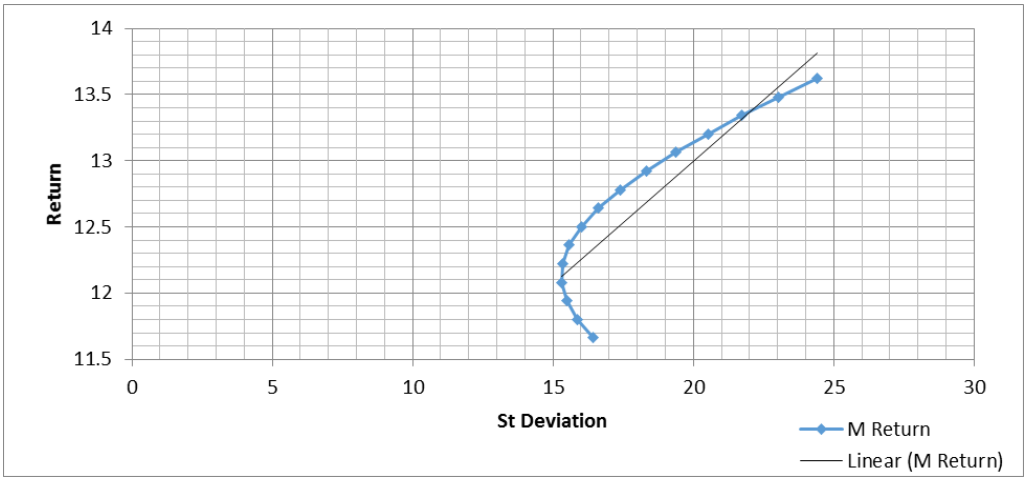


Table 16: Analysis of the SENSEX, BOND and MCX Metal Portfolios

Portfolio	SENSEX	BOND	MCX Metal	M Risk	M Return	Sharpe Ratio
A	0.8	0.1	0.1	16.41332	11.6604	0.405792
B	0.75	0.1	0.15	15.8539	11.8005	0.428948
C	0.7	0.1	0.2	15.48094	11.94061	0.448333
D	0.65	0.1	0.25	15.30807	12.08072	0.462548
E	0.6	0.1	0.3	15.34206	12.22083	0.470656
F	0.55	0.1	0.35	15.58156	12.36094	0.472413
G	0.5	0.1	0.4	16.01735	12.50105	0.468308
H	0.45	0.1	0.45	16.63401	12.64116	0.459369
I	0.4	0.1	0.5	17.41233	12.78126	0.446882
J	0.35	0.1	0.55	18.33174	12.92137	0.432112
K	0.3	0.1	0.6	19.37215	13.06148	0.416138
L	0.25	0.1	0.65	20.51516	13.20159	0.399782
M	0.2	0.1	0.7	21.74461	13.3417	0.383621
N	0.15	0.1	0.75	23.04666	13.48181	0.368028
O	0.1	0.1	0.8	24.4097	13.62192	0.353217

Figure 18: Efficient frontier of the SENSEX, BOND and MCX Metal Portfolios



Result Discussion:

For the combination of Equity, Bond and commodity total 15 portfolios have been created with varying proportion of equity and commodity index. The bonds were added to the portfolio so as to provide the downward side risk protection as they had the lowest risk but since the returns on bond were also lowest so there was no point in increasing the proportion of investment in bond. Therefore the proportion of bond was kept fixed at 10% in the entire portfolios.

Result for the combination of SENSEX, BOND and MCX COMDEX Portfolios:

The empirical evidence here indicates that the portfolio having major proportion of SENSEX is having low risk and higher returns as compared to portfolio having major proportion of COMDEX. This suggests that optimal portfolio would be having major proportion of SENSEX as compared to COMDEX. Out of the fifteen portfolios that have been framed Portfolio F is the optimal portfolio. It had the highest risk adjusted return ratio of 43% and was obtained when equity, bond and portfolio have been combined in the proportion of 55%, 10% and 35% respectively. On the efficient frontier also Portfolio F comes out to be the optimal portfolio.

Result for the combination of SENSEX, BOND and MCX AGRI Portfolios:

The risk of the portfolio having major proportion of commodity is much higher and the returns were much lower as compared to the portfolio having major proportion of equity. This again gives an indication that in the optimal portfolio the major proportion will be of equity. Empirical evidence indicates that portfolio C is the optimal portfolio with the highest Sharpe ratio of 37%.Portfolio C was obtained when equity, bond and commodity has been combined in the ratio of 7:1:2 respectively.

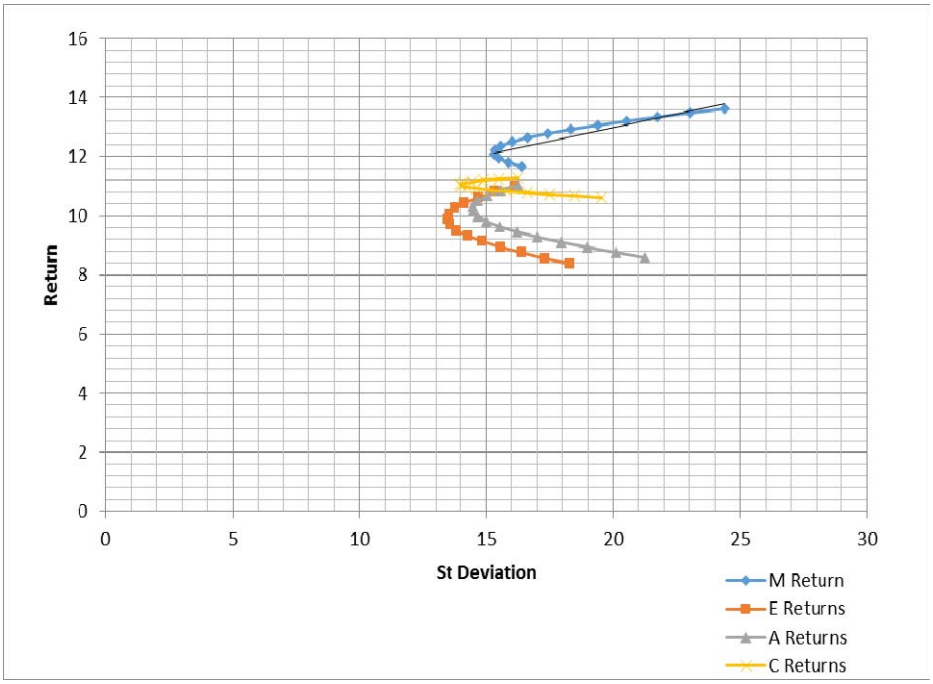
Result for the combination of SENSEX, BOND and MCX Energy Portfolios:

In this case also the risk was higher and the returns were lower for portfolio O which has higher proportion of commodity as compared to portfolio A. The highest Sharpe ratio was found to be 38% for portfolio D having equity, bond and commodity combined in the ratio of 65%, 10% and 25% respectively. The similar results were demonstrated by efficient frontier.

Result for the combination of SENSEX, BOND and MCX Metal Portfolios:

In case of MCX Metal quite different from other commodity indices risk and return of portfolio O was higher as compared to portfolio A. Out of the fifteen portfolios that have been framed Portfolio F is the optimal portfolio. It had the highest risk adjusted return ratio of 47% and was obtained when equity, bond and portfolio have been combined in the proportion of 55%, 10% and 35% respectively. On the efficient frontier also Portfolio F comes out to be the optimal portfolio.

Figure 19: Combined Efficient frontier of SENSEX , BOND and Commodity Indices



Result of Combined Efficient Frontiers:

The result of combined efficient frontier depicts that out of the four commodity indices in combination with SENSEX and BOND, MCX Energy provides the maximum downward side risk protection. The highest risk was possessed by combination of

SENSEX, BOND and MCX Metal. In a similar way out of the four commodity indices in combination with SENSEX and BOND, the highest risk adjusted was provided by MCX Metal. If we compare MCX AGRI and MCX Energy then at the similar level of risk the return of MCX AGRI is higher as compared to MCX Energy. This suggests that an investor who is risk averse and whose preference is risk protection will prefer to invest in combination of SENSEX,BOND & MCX Energy whereas an investor who gets utility by taking more risk for more returns will prefer to invest in combination of SENSEX ,BOND & MCX Metal. Investor having inclination towards moderate risk return would tend to invest in MCX AGRI along with SENSEX and BOND.

4. **Conclusion**

The study provides empirical evidence on the use of commodity future indices in context of portfolio. Firstly from the diversification aspect the study demonstrates that due to very low degree of positive correlation and negative in some cases commodity futures provides the diversification benefit in combination with equity and bond in the portfolio. Secondly in context of providing hedge against inflation since MCX COMDEX and MCX Energy are related positively with the inflation therefore they can be used as an excellent hedging tools against inflation. Lastly the result of the study indicates that when commodities are considered in a portfolio context for the first set having combination of equity and commodity optimal portfolios have been obtained. For COMDEX and MCX Metal optimal combination ratio was 65% of SENSEX and 35% of commodity. For MCX AGRI the ratio is 7:3 and for MCX Energy the ratio is 3:1 for SENSEX and commodity respectively.

For the second set of portfolio having combination of Bond and Commodity indices the optimal portfolio has not been obtained in any of the case. Therefore the evidence of the study suggests that a rational investor should not invest in a combination of bond and commodity. For the final set of portfolios having combination of equity, bond and commodity indices optimal portfolio have been obtained with each of the commodity index. For COMDEX and MCX Metal optimal combination ratio was 55% of SENSEX, 10% BOND and 35% of commodity. For MCX AGRI the proportion is 70%, 10%,20% and for MCX Energy the proportion is 65%,10% and 25% for SENSEX, Bond and commodity respectively.

Results of the combined efficient frontier also revealed that an investor who is risk averse and whose preference is risk protection will prefer to invest in combination of SENSEX, BOND & MCX Energy whereas an investor who gets utility by taking more risk for more returns will prefer to invest in combination of SENSEX, BOND & MCX Metal. Investor having inclination towards moderate risk return would tend to invest in MCX AGRI along with SENSEX and BOND.

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