DYNAMICS OF RETURNS AND CONDITIONAL VOLATILITY: HEDGING INSIGHTS AND PORTFOLIO IMPLICATIONS OF OIL AND GOLD INVESTMENTS IN PAKISTANI STOCK MARKET

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Abstract

This thesis explores the dynamics of returns and conditional volatilities for stocks at sector level in Pakistan and commodities such as oil and gold with a view to shed light on the portfolio implications and hedging insights. We utilize DCC-GARCH, ADCC-GARCH and GO-GARCH models for the sample period January 2000 to December 2014. The conditional volatility parameters extracted from multivariate GARCH models; are used to construct the optimal hedge ratios and portfolios weights between sector stocks-oil/gold pairs. The results of the study signify that long and short term volatility persistence are evident of volatility clustering in all markets under consideration. The results for asymmetric volatility dynamics indicate that negative innovations in returns for all series except for gold asset tend to increase the future volatility more than positive innovations of similar size. This pushes the investors to consider safe haven assets during turbulence time in stock market. Furthermore, the results of the study demonstrate that conditional correlations are mean reverting across all pairs during the entire period of the study. The time-varying patterns of conditional correlations between all pairs help to investigate the hedge and safe haven properties for oil and gold assets. During the economic downturns 2007-2009, a downward pattern in correlations displays that oil asset play a role of safe haven asset only for health care industrial sector stocks whereas gold maintains status of safe haven asset for all sector's stock except telecommunication and utilities industrial sectors. The evaluation of risk diversification in stocks portfolio and hedging potential of oil and gold assets for all pairs indicate that adding oil and gold to a stock portfolio improve the overall risk-adjusted return performance. For instance, investors in Pakistan should allocate more stock than oil and gold assets in their portfolios. The stock market's investment risk can be hedged by taking the short position in oil and gold markets. The time-varying pattern in hedge ratios for all sectors and alternative assets indicates that investors should update their hedge position regularly according to market conditions. Finally, the efficiency of allocation weights of oil and gold assets in risk reduction varies across industrial sector stocks. The findings of the thesis enable the policy makers, portfolio managers as well as investors in their decision related to the markets under consideration.

Keywords: - Gold, Oil, Industrial Sector Indices, Dynamic Correlations, Time-varying Hedge Ratios, Optimal Portfolio Weights, Multivariate GARCH Models.

DEDICATION

I would like to dedicate this thesis to my beloved parents, dearest wife and dearest daughter and not to forget the professional support of my brothers and sisters who have been a great source of inspirations throughout my life and they have provided a lot of moral support and enabled me to become what I am today. Especially my father and mother supported and courage's me a lot which I will never forget. I would also like to dedicate this effort to my honorable teachers, especially Dr. Muhammad Khan and Dr. Syed Jawad Hussain Shahzad who inspired me to generate and discriminate knowledge.

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LIST OF ABBRIVATIONS

ADCC: Asymmetric Dynamic Conditional Correlation

AR: Autoregressive

ARCH: Auto-Regressive conditional Heteroscedasticity

BEKK: Baba Engle Kraft and Kroner

CAPM: Capital Asset Pricing Model

CCC: Constant Conditional Correlation

CME: Chicago Mercantile Exchange

DCC: Dynamic Conditional Correlation

DVEC-GARCH: Diagonal VEC-GARCH

FTSE: Financial Time Stock Exchange

GARCH: Generalized Auto-Regressive conditional Heteroscedasticity

GO-GARCH: Generalized Orthogonal GARCH

HR: Hedge Ratio

ICB: Industry Classification Benchmark

KSE-100 Index: Karachi Stock Exchange 100 Stock Index

MANIG: Multivariate Affine Negative Inverse Gaussion

M-GARCH: Multivariate GARCH

MPT: Modern Portfolio Theory

OECD: Organization for Economic Co-operation and Development

OLS: Ordinary Least Squares

OPEC: Organization of Petroleum Exporting Countries

PMEX: Pakistan Mercantile Exchange

PSX: Pakistan Stock Exchange

UK: United Kingdom

US: United States

VAR-GARCH: Vector autoregressive-GARCH

VEC-GARCH: Vector Error Correction-GARCH

WTI: West Texas Intermediate

CHAPTER 01

INTRODUCTION

1.1 Background of the Study

Frequent financial crisis in the world markets have raised problems for individual and institutional investors, financial analyst as well as portfolio managers for investment decisions in traditional investment classes such as stocks and bonds. Due to fragile market conditions, the interest of the investors have seen a shift in alternative means like commodities (Edwards & Caglayan, 2001; Georgive, 2001; Erb & Hervey, 2006; Chong & Miffre, 2010; Tang & Xiong, 2010) because commodities have potential to minimize the risk inherent in their traditional assets. The stock markets witnessed a sudden drop as the commodities prices like oil and gold got an excellent high record at the time of economic turbulence 2007-2009. However, on the contrary, the temporary fall in stock markets regained the lost status and consequently commodities have shown a downward trend in prices (Nielsen, 2013). The mentioned trend in rise and fall in prices shows a negative correlation between equities and commodities which have proven to be attractive for diversification benefits. The diversification benefits can be achieved at their best by adding different asset classes that maintain negative or low correlation (Bansal, Kumar, & Verma, 2014). Furthermore, another means employed by the investors to fix this problem is to invest in commodities while reducing risk of stocks and bonds (Bodie & Rosansky, 1980; Lee, Leuthold, & Cordier, 1985; Anson, 1999; Edwards & Park, 1996).

Traditionally, oil and gold have shown a low or a negative correlation with the stock markets and are helpful for portfolio diversification and hedging (Sadorsky, 2014b). In addition, oil, among energy commodities, and gold, among precious metals, are most tradable commodities in the world (Barunik, Kocenda, & Vacha, 2016). For production, the crude oil consumption has shown a dramatic increase during the last decades as oil is being used a most important source of input (Bildirici & Turkmen, 2015). According to US Energy Information Administration, 95.6 million barrels oil had been consumed in 2016 around the world. The fluctuation in oil prices brings inflationary pressure and also affects: financial performance, retained earnings, cash flows and stock returns of the firms (Huang, Masulis, & Stoll, 1996). However, a rise in oil prices unfolds a negative/positive shocks on the countries importing/exporting oil e.g. higher prices manifest a positive impact in oil exporting countries (Cunado & de Gracia, 2014; Ramos & Veiga, 2013; Arouri & Rault, 2012; Li, Zhu, & Yu, 2012; Broadstock, Cao, & Zhang, 2012; Peersman & Van Robays, 2012; Filis, Degiannakis, & Floros, 2011; Kilian & Park, 2009; Eryigit, 2009; Park & Ratti, 2008). In case of oil importing economies, the volatility in oil price puts forth a negative impact on expected cash flows and financial markets' returns (Cunado & de Gracia, 2014; Caporale, Ali, & Spagnolo, 2014; Wang, Wu, & Yang, 2013; Narayan & Narayan, 2010; Eryigit, 2009; Boyer & Filion, 2007; Cong, Wei, Jiao, & Fan, 2008; Sadorsky, 2001;). Due to the negative effects of oil prices, the investors have shifted from risky investment to safe assets, keeping the gold as another source of investment (Yaya, Tumala, & Udomboso, 2016).

Historically, gold is considered as a medium of exchange (Chang, Della Chang, & Huang, 2013); a safe haven asset; especially during crisis periods in financial markets (Baur & Lucey, 2010) ; a store of value (Baur & McDermott, 2010); a risk diversification asset (Davidson, Faff, & Hillier, 2003); a portfolio diversification instrument (Wang & Lee, 2011); hedge and derivative asset (Narayan, Narayan, & Zheng, 2010; Wang, Wei, & Wu, 2011); among other metals like silver, platinum and palladium. Despite the importance of gold, theoretical associations between gold and oil assets are linked through an inflation channel (Hooker, 2002; Hunt, 2006; Narayan *et al.*, 2010). A rise in international crude oil prices brings inflationary pressure on an economy which rises the transportation and production cost in the oil importing countries. Under these circumstances, the gold has been identified as a distinctive alternative asset of inflation hedge, such that an upward movements in oil prices leads to a rise in demand of gold (Van Hoang, Lahiani, & Heller, 2016). Therefore, gold prices move up and a positive correlation between oil and gold assets is maintained during an inflationary period (Tiwari & Sahadudheen, 2015). Due to positive association between these two commodities, the investor invests in gold market to balance their portfolios as a result of increase in the general price level (Ghosh, 2011).

Moreover, a rise in the general price level undermine the value of stock as companies earn less profit and investors shift their investments from the riskier stock market (by selling shares) to the gold market (by buying gold) in order to store value of assets (Reboredo, 2013; Pettinger, 2011). This trend elaborates a inverse correlation between gold and stock markets (Gurgun & Unalmis, 2014; Hood & Malik, 2013). Furthermore, not only oil but gold also holds a significant position, due to a financial instrument for portfolio diversification, because gold has a negative or low correlation with stock markets both at aggregate as well as at sector level (Arouri & Nguyen, 2010; Daskalaki & Skiadopoulos, 2011; Sadorsky, 2014b).

1.2 Problem Identification

The financial turbulence 2007-2009[1] has created uncertainty in the financial system and shattered the investors' trust on stock markets which motivated them to consider the alternative assets-class like commodities as a part of diversified portfolio of stocks (Arouri, Lahiani, & Nguyen, 2015). Most often, commodity sector remains as a cushion during weak financial systems due to poor confidence of individual and institutional investors during the economic turbulence[2] and cause inverse correlation between equity market and commodity market (Erb & Harvey, 2006). By some estimates, investors made an investment of dollar 13 billion in 2003 which further increased more than $200 billion in 2008 in commodities (Basher & Sadorsky, 2016).

However, Pakistani economy is not directly affected by the economic unrest 2007-2009 due to relatively disconcerted connectivity with the global economy as compared to the neighbors like India and China (Draz, 2011). Even so, an indirect effect has been manifested in form of trade losses. Another influencing factor was the prevailing local financial problems caused due to short sighted future strategies to tackle these trade losses (World Bank, 2009). The aforementioned crisis squeezed Pakistan's real gross domestic product from 8% to 3 % causing a swift increase of 25% in prices/inflation along with consequent unemployment (Nanto, 2009; Martin, & Kronstadt, 2009). Other factors that have affected Pakistani economy are intangible external forces, political unrest and economic challenges (Husain, 2009). In current

[1] According to Business Cycle dates of National Bureau of Economic Research (NBER) Financial crisis start in December 2007 and end in June 2009.
[2] Does gold act as hedge in the currency and stock markets in Asia? Retrived from website:https://umexpert.um.edu.my/file/publication/00005571_115850.pdf

era, the economic growth in Pakistan's economy[3] is experiencing diverse problems like perennial structural issues, security issues, energy crisis, difficult geo-political situation and fiscal imbalances. Among these challenges, the stock markets are the bench mark of financial and economic growth of a country. The role of equity markets is multifaceted like ensuring investment opportunities for domestic as well as international investors and to work as a conduit to promote economic development. Furthermore, equity prices also provide fruitful information regarding the financial stability and serve as an indicator of financial crisis (Gadanecz & Jayaram, 2008). Specifically in the context financial market of Pakistan, Pakistan Stock Exchange (PSX) has scored 14,814 points in December 2007 and rose up to a peak of 15,373 points in April 20, 2008 (Mohammad, Hassan, & Ali, 2009). A major financial crash was observed with 9,144 points on August 27, 2008 (Peiris, 2008) which declined further by 4,929 points in January 2009. The sudden decline of the stock market caused a mega loss of billions of rupees following the decreasing trend in KSE-100 Index. Afterwards, growing trend of investments prevailed and KSE-100 Index reached up to 47,807 points till the end of December 2016. It reflects a fluctuation in equity market that would continue in the near future. During the time of unpleasant financial markets, investors strived to minimize/avoid large losses. In brief, investors dislike bearish trends and avoid losses in equity market through hedging or portfolio diversification. Due to this reason, diversifying the portfolio through hedging has been unpresidented (Backmann, Berger, & Czudaj, 2015).

[3]According to Economic Survey of Pakistan 2016-17 (http://www.finance.gov.pk/survey/chapters_17/04-Fiscal.pdf)

In this context, various factors coordinate with each other in macroeconomic perspectives. The financial markets are impacted by various interconnected variables such as gold, oil prices and their volatilities (Shahbaz, Tahir, Ali, & Rehman, 2014). Among these variables, gold is considered and used as a precious commodity in international currency reserve. Many countries in the world hold a specific proportion of their foreign reserves in gold (Chang *et al.*, 2013). According to the World Gold Council, the gold reserves have increased from 2310.1 million US dollars to 2742.9 million US dollars (17.12 %) in the third quarter of 2016 as compared to the previous years. The gold demand has raised to 16.3 % in 2016 (Q2) on an yearly basis in Pakistan. Gold is serving a role of monetary asset in the financial market and has been considered as: a risk diversifier asset (Davidson *et al.*, 2003); a portfolio diversification instrument (Wang & Lee, 2011); and provision of a better hedge opportunity due to holding an appropriate hedge instrument for financial assets or portfolio (Baur & Lucey, 2010).

In context of energy, the crude oil is important player in production due to its prices which are determined by demand and supply shocks. According to the US Energy Information Administration, the crude oil imports have been increased to 12 % since 2014 to 2015. The oil consumption has been increased dramatically, on average 431,000 barrel per dollar in 2015, in Pakistan. In boarder scenarios, a variation in crude oil prices disturbs the import bill of an economy. Ji (2012) argues that the world financial crisis of 2007-2009 has disturbed the crude oil market mechanism and has strengthened the relationship between crude oil prices and the stock market after the crisis period.

Furthermore, the main feature of financial markets is to make the investors to hold diverse expectations and choose defensive strategies like hedge assets or purchasing safe haven assets such as commodities to complement the composition of their traditional portfolio of stocks and bonds (Huang, An, Gao, & Huang, 2015). Moreover, it is well known evidence that there is negative association between returns and stock returns volatility (Chen, Chung, and Ho, 2011). The volatility of equity market is asymmetric and stock prices fell down as a result of negative correlation between conditional volatility and returns in stock markets. Hence, financial leverage increases as result of negative trend in stock return which makes riskier the stock. To compete the shocks in stock markets, the financial analysts, investors and portfolio managers ought to be more rational and cautious while framing their portfolios (Christensen, Nielsen, & Zhu, 2015). On the whole, the commodities like oil and gold are strategic commodities and their price movements have important implications for the investors, portfolio managers, risk managers and policy makers. Furthermore, oil and gold also maintain a low or a negative correlation within the stock market (Sadorsky, 2014b) because their volatilities negatively impact the stock market and explain the stock prices (Raza, Shahzad, Tiwari, & Shahbaz, 2016). This discussion in context of gold and oil means that gold and oil are desirable assets in traditional portfolio of stocks for investors to hedge the risk.

This thesis aims to provide knowledge to the investors, portfolio managers about returns and volatility dynamics among stock market and commodities like oil and gold using multivariate GARCH models. In addition, the problem statement is based on comprehensive analysis of the hypothesis “whether presence of asymmetric news impact is different in financial assets and will oil or gold instruments are useful as a potential hedge or safe haven for sectoral stocks in order to minimize the portfolio risk during financial market turbulence or not”.

1.3 Research Gap

The existing literature shows a scarcity of studies investigating the correlations among commodities such as oil, gold and equities in Pakistan. For example, Ansar and Asghar (2013) established a weak positive relation among oil prices, consumer price index and stock market index in Pakistan. Irshad, Bhatti, Qayyum, and Hussain (2013) originated a temporary relation among oil, gold, and the stock market during the study time from 2002 to 2010 in Pakistan. Tufail and Batool (2013) suggested that gold prices significantly impact the stock prices in Pakistan. Siddiqui and Muhammad (2014) also established a positive correlation between the prices of oil asset and stock market in Pakistan for the study period from 2003 to 2012. Recently, Khan, Aziz, and Merani (2016) concluded short-term relationship between gold prices and KSE-100 Index for time span from 1993 to 2014. Further, Najaf, Najaf, and Yousaf (2016) documented a negative relation among stock market, oil and gold market over the period of study from 1996 to 2013. To the best of my knowledge, this study offers novelty to capture the diversification benefits of oil and gold assets, allocation of alternative assets in traditional portfolio of stocks and their hedging mechanism at industrial sector level by using multivariate GARCH models in Pakistan, which remain an unexplored area. During the adverse financial market situations, investors and portfolio managers require minimum risk or avoiding the bearish trends in stock market through hedging and portfolio diversification. By filling the above gap in literature, this study helps the investors and portfolio managers to choose defensive strategies such as hedge or purchase safe haven assets to complement the composition of portfolio of stocks. Furthermore, previous literature documented that volatilities of commodities explain stock prices and simultaneously oil and gold volatilities reflect negative impact on stock market (Lin, Wesseh, & Appiah, 2014; Sadorsky, 2014).

This study offers another novelty to explore the presence of asymmetric volatility dynamics in oil, gold assets and stocks at sector level have also remained an unexplored area in Pakistan. The analysis of aggregate stock market index breakdown into sector level indices is important because it possibly counters the biases inherent in the use of aggregate equity index that may mask the sector specific characteristics (Arouri, Jouini, & Nguyen, 2011). In addition, differences exist among sectors with respect to their structure, level of competition and role of oil as direct or indirect input/output in that particular sector (Xu, 2015). The previous literature also shows that some sectors of an economy may be severely affected by price volatility of oil because degree of response may vary across the sectors. Moreover, the novelty of applying the multivariate GARCH models on is based on well known fact that most of the studies use financial time series with features of volatility clustering, asymmetric effect and heavier tails. This makes the multivariate GARCH models a most feasible choice to apply on such series rather than applying the simple econometrics models such as co-integration test, vector error correction model. The study of these variables will enhance hedging benefits and diversification opportunities to investors for rebalancing their portfolio of stocks with dynamic correlation models over the time, especially in the context of Pakistani economy.

1.4 Research Questions

This thesis focuses on the returns and volatility dynamics of stocks and alternative assets and portfolio implication of stock, oil and gold investments in Pakistan by using sectoral stock indices. The problem statement therefore is broken down into research question.

1. Is the presence of asymmetric impact of news different in oil, gold assets and industrial sectors in case of Pakistan?

2. Is relationship between stock-oil/gold pairs time-varying?
3. What are the hedge and safe haven dynamics of alternative assets when added to a stock portfolio?
4. Do the hedge properties of oil and gold assets depend on the business nature of a particular sector in Pakistan?
5. What are the optimal portfolio choices for investors at sector level stocks, considering the hedging and safe haven properties of oil and gold assets?

1.5 Objectives of the Study

The objectives of this thesis are manifold as given below.

1. To investigate the presence of asymmetric impact of news in oil, gold assets and industrial sectors in Pakistan.
2. To examine the sector base time-varying relationship between stock, oil and gold assets.
3. To explore the hedge and safe haven dynamics of alternative assets when added in sectoral stocks portfolio.
4. To scrutinize the hedge properties of oil and gold assets depend on the business nature of a particular sector in Pakistan.
5. To explore the optimal portfolio choices for investors at sector level stocks, considering the hedging and safe haven properties of oil and gold assets.

1.6 Contribution of the Study

This thesis fills the research gap in literature in context of Pakistan by making contribution for investors, commodity market participants, energy traders, policy makers and portfolio managers. First, gold is regarded as a safe haven investment and hedge asset against inflation and stock returns. In literature numerous researchers found that investors should gather the information or analyze the market condition before incorporating the oil and gold assets into their traditional portfolio in order to mitigate the risk. The findings of this thesis contribute the portfolio knowledge, which facilitate the investor in the portfolio decision making. Furthermore, this thesis facilitates them in finding the optimal allocation of share of commodities like oil and gold into portfolios of stocks at sector level. Secondly, the findings of this thesis help the market percipients in understanding the oil and gold volatility mechanism and stock market in term of enhancing the performance of their hedging strategies. Further, this thesis also provides the useful information to energy traders regarding risk control and portfolio opportunities and financial analysis who need thorough understanding of the volatility of assets.

Thirdly, this study uses conditional variance and correlations specifications such as DCC-GARCH and ADCC-GARCH, one factor model such GO-GARCH model in order to examine the co-movement of stocks with oil and gold assets. Further, this thesis also uses these models in order to access the usefulness of alternative assets (oil and gold) for portfolio construction and hedging. The choice of these models is motivated by several reasons to account the features of time series data. **1).** Engle (2002) presented a DCC-GARCH approach, is appropriate to examine the symmetry in time series (Arouri *et al.*, 2011; Lin *et al.*, 2014), dynamic correlations among returns for financial variables and commodities (Ciner, Gurdgiev, and Lucy, 2013). Previous authors (Hammoudeh, Yuan, McAleer, & Thompson, 2010; Chang *et al.*, 2013) applied the DCC-GARCH model to examine the time-varying correlations and hedging strategies among financial assets. This model also measures the persistence in both conditional correlation and volatility. **2).** The ADCC model of Cappiello, Engle, & Sheppard (2006) which is extended form of the DCC, allows to capture the characteristic of financial time series 'asymmetry' (Chkili, 2016). The asymmetric-DCC model separately estimates negative and positive information (Chkili, Chaker, Masood, & Fry, 2011). **3).** The GO-GARCH model (Van der Weide, 2002) captures effects of volatility spillover under linear transformation, time-varying correlations and volatilities, and asymmetric volatility spillover. The GO-GARCH model is less use in practice but tricky to estimate (Basher & Sadorsky, 2016). Finally, these models shed light on portfolio diversification, the allocation weights of alternative assets and hedge ratios for stocks-oil/gold portfolios holding at sector level in Pakistan.

Fourthly, for optimal portfolio holding, the results of this thesis on portfolio weights between industrial sector stocks oil/gold pairs help the portfolio managers on how much oil or gold assets could constitute in portfolios of stocks for an overall risk minimization. The finding of this study helps the investors and firms sensitive to oil price volatility for making better decision related to oil price risk hedging. Finally, the analysis of hedging reveals that the mean value of hedge ratios among industrial sectors and gold pairs is slightly higher than the hedge ratios of stocks and oil portfolios. Further, a long position in the stocks at sector level can be hedged by taking short position in oil/gold assets. The higher average value of hedge ratios between stocks/gold portfolios indicates that gold offers higher diversification as compared to the oil asset.

1.7 Significance of the Study

The dynamics of returns and volatilities among stock, oil and gold prices and their respective evaluation is an important topic for academicians as well as for policy makers, investors and portfolio managers. At time of economic unrest 2007-2009, the correlation between different assts has increased and raised concerns among investors and portfolio managers who always require minimum risk and higher returns through portfolio diversification for holding risky stocks.

This thesis help the investors and portfolio managers in the area of portfolio diversification and risk management by adding the oil and gold investments, in the stock portfolio, as a best diversifier in portfolio of stocks which are known to be impacted by the oil and gold prices shocks. Specifically, this study explores the portfolio diversification benefits of oil and gold investments and reaction of stock prices to the oil and gold price shocks at sectoral level in Pakistan. Notably, different sectors have a different reaction to the oil price movements and also have varying relationships with the gold prices. For example, the sectors which heavily use oil as an input for their production process may react more to the oil price movements and those with less reliance on the oil supply and demand may react differently. Furthermore, the applications of multivariate-GARCH provide the importance by focusing on characteristic of financial time series such as volatility clustering and time-varying correlations and heavier tails. The estimation of asymmetric features of financial time series indicate that negative news put forth a vital impact on returns as compared to positive news of equal size which pushes the investors to explore the assets which have hedge and safe haven properties with the intention of protection of their investments for the period turbulence in financial markets. Furthermore, Mainik, Mitov, and Ruschendorf (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by abnormal returns originate from assets returns with heavy-tail distribution which highlights the importance mixed assets in portfolio for investors and portfolio managers. A time-varying correlation patterns facilitate the investors to evaluate the investment risk, hedging, safe haven and the allocation of assets in portfolio.

On the other hand, sectors like consumers' discretionary and their profitability are impacted by the inflation level in the economy. Since it is well known that gold provides a good hedge against inflation, therefore, it can be inferred that gold may provide better diversification to the sectors which are categorized as cyclical stock. Based on these lines of argument, the present study will provide the first empirical evidence on the dependence between stocks, oil and gold returns at sector level in Pakistan. The assessment of oil price fluctuates in world oil market and its impact on the sectoral stocks in Pakistan will help policy makers to formulate regulations and policies for the oil market mechanics. It is worth noticing that Pakistan economy is currently suffering from the worst energy crises of all times and the local oil prices have drastically changed. Therefore, the findings of this study are expected to enhance our knowledge of the oil price dynamics and its impact on the growing financial market of Pakistan.

1.8 Research Theories

The portfolio theories such as modern portfolio theory and capital asset pricing model provide the theoretical foundation of hedging between various assets. The capital asset pricing model (CAPM) describes the association between return and risk of asset. Therefore, risk of the portfolio will reduce by holding a well diversified portfolio and systematic risk impact the expected asset's returns which cannot eliminate through diversification. However, the fundamental assumption of modern portfolio theory (MPT) is the integration or interdependence between financial markets. The MPT mostly highlight the diversification issue based on above underlying assumption. This theory endeavors to maximize the expected portfolio's return at given level of portfolio's risk or minimize the portfolio's risk at given level of expected return (Sharp, 1964; Linter, 1965).

The hypothesis of hedge and safe haven asset has introduced by Buar and Lucey (2010). A hedge asset is defined as an asset which is uncorrelated or having a negative correlation with other assets on average and does not have the feature of loss reduction in extreme declining time of stock market. Additionally, a safe haven asset is defined as an asset which is uncorrelated or having a negative correlation with the stock market in the crisis times of stock market, and gold maintains this property.

Jastram (1977) introduced a theory on gold and inflation relation named "The Golden Constant Theory". According to this theory, gold investment retains its purchasing power and responds to inflation by increasing returns. The prices of gold do not chase the commodity prices; commodity prices return to index level of gold over and over.

1.9 Overview of Thesis Structure

This part gives an overview of the whole thesis, as follows.

Chapter 1

Chapter one briefly reports the background that motivates us to choose the study topic. Moreover, this chapter explains the problem identification and, research gap found in literature; subsequently, we draw upon research questions and main objectives. Similarly, significance, contribution of the thesis and research theories are presented in the second half of the chapter one.

Chapter 2

Chapter two presents literature review related to oil market, stock market, gold and oil characteristics, and gold market to frame the research gap. However, the first part of this chapter begins with the review of literature on variation in oil prices and its impact on stock markets. Further, the aim of the chapter is to provide information on gold characteristics as a best diversifier in portfolio, a safe haven asset, as hedge against inflation, relationship of gold with investment, currencies as well as other valuable commodities. The relationship between gold, oil assets and financial markets are presented the second part of this chapter.

Chapter 3

This chapter presents the methodology used to reach at the empirical findings. The chapter starts with description of data sample, time frame of selected sample data, splitting the Pakistan Stock Exchange (PSX) into industrial sector indices and data collection source or database. The second part of this chapter provides the multivariate GARCH models, their selection and estimation method that enhances our understanding of the statistical methodology and empirical findings. Finally, the chapter terminates with allocation weights of oil and gold assets in sectoral stock and dynamic hedge ratios which provide the information to the readers regarding contribution of oil and gold into portfolio of stocks at industrial sector level as well as hedging mechanism of above commodities.

Chapter 4

The preliminary empirical findings of the study are provided in chapter 4. This chapter is further divided into four parts; first, the descriptive statistics of time series data for gold, oil and stock market sectors and their Pearson's correlation patterns are demonstrated. Secondly, dynamic conditional correlations pattern based on GARCH methodology are presented. Thirdly, the dynamic pattern of hedge ratios are presented in graphical form, the average values of hedge ratios and allocation weights of oil and gold assets in industrial sector stocks are presented in last part of the chapter. Fourth, this also chapter presents the discussion on basic and empirical findings and how these results answer the research questions. Further, the discussion on results starts from descriptive statistics and ends on hedge ratios and optimal allocation weights of oil and gold assets in portfolio industrial sector indices.

Chapter 5

This chapter reports a conclusion of thesis and elaborates recommendations and suggestions for investors, portfolio managers, and commodity market participants as well as for the policy makers. At last, this study suggests some possible extensions for future research in this area.

CHAPTER 02

LITERATURE REVIEW

2.1 Oil Price Volatility and Stock Markets

Economic theory provides us an existing association between prices for oil and equity. The economic theory which was formulated by Fisher 1930 and Williams 1938, the present value of an asset is a reflection of the expected discounted future cash inflows of that asset. It implies that the value of the asset is highly impacted by the factors that account for the discounted cash inflows. Thus, oil is considered as a vital factor of production and put forth its impact the economy both directly and indirectly through stock returns for economies importing and exporting oil. Hence, a many researchers have investigated the oil shocks' impact on worldwide stock markets.

2.1.1 The Negative Impact of Oil Price Shocks and Stock Markets

Cunado and de Gracia (2014) examined the dynamics of oil price uncertainty in European countries by using vector autoregressive and vector error correction model. A sample of twelve European economies from 1993 to 2011 was employed. The study explained that stock markets in European countries behave negatively to shocks initiated by oil price changes. Caporale *et al.* (2014) investigated the impact of oil price volatility on ten sectoral equity indices in China. The study uses data from 1997 to 2014 by performing the bivariate GARCH-M model. They proposed a negative impact of price volatility of oil on oil and gas sector and financial sector, which is determined by supply side shock during the time horizon under consideration. The study also suggests that investors cannot use oil and stock as a hedging tool for the diversification purpose in their portfolios during 1997 to 2014.

Lee and Chiou (2011) provided the evidence to validate a negative influence of oil price shocks on Standard & Poor 500 Index in USA by employing daily traded data from 1992 to 2008. The authors reported that fluctuations in oil prices negatively affect the returns in equity markets. Furthermore, Filis *et al.* (2011) also study the behavior of movement of oil prices towards equity markets. They used the DCC-GARCH model developed by Eagle (2002) by bringing into use the data from 1987-2009 and reaffirmed that all stock markets have been influenced negatively due to oil price changes during the crisis in oil importing countries. Filis (2010) reports the influence of oil prices on stock market in Greece during 1996-2008 by employing monthly data and determines a significant negative influence on stock market due to oil prices. Another study done by Sadorsky (1999), scrutinize the linkage between fluctuations in oil prices and equities for the United States. The study utilizes the vector auto regression (VAR) model comprising the time span from 1947 to 1996. A negative impact is found with regards to fluctuations of oil price towards returns in US equity market. Furthermore, movements in oil prices also effect on economic activity but this impact is found to be symmetric.

Jones and Kaul (1996) were the first to analyze the US, UK, Canada and Japanese stock market's reaction towards oil price volatility. They performed dividend cash flow valuation model of Campbell (1991) on quarterly data, collected during 1947-1991 for United States, 1960-1991 for Canada, 1979-1991 for Japan and 1962-1991 for United Kingdom respectively. They empirically documented different responses of oil price shocks across international stock markets. Especially, this study also observes that an impact of oil price shocks carries on current and future cash flows of companies as well as their stock returns. They provide the evidence that as the oil price increases, company's profits evidently decline and cash inflows also deteriorate as a result of increase in production costs as well as inflation increases. With a decrease in the value of shareholders, stock returns correlate negatively to oil price shocks.

Further, Kilian and Park (2009) performed a study in United States on monthly data comprising time period from 1973 to 2006. They studied the price volatility of oil asset and national equity market by dividing the oil price fluctuations into supply and demand shocks, respectively. They highlighted that the oil price changes which are driven by demand shocks, negatively impact on the overall stock returns in US economy. Miller and Ratti (2009) performed the similar study in OECD countries from 1971 to 2008 by applying vector error correction model with multiple breaks. They aggregates the results in detail that a long term correlation existed between the price for oil asset and equity market from 1971 to 1980 and from 1988 to 1999 but this relationship between these variables was not considerably different during the time period 1980-1988 in comparison to previous time horizon. Moreover, a negative association was evidence after 1999.

Nandha and Faff (2008) applied factor market model on equity indices of 35 industrial sectors and oil prices which covered sample period from 1983 to 2005 on monthly basis. The study determines that a rise in prices for oil asset has a negative impact on corporate earnings and output, where oil is employed as a factor of input. Similarly, unfavorable influence of price volatility of oil has been observed on prices in equity sector which significantly decreased the returns of stock markets. The stock markets were negatively affected due to oil price volatility during the turmoil except for oil and gas sector as well as for mining industries. Moreover, the study finds that an increase or decrease in oil prices would have different impact on stock market returns.

Further contribution made by Basher and Sadorsky (2006) in emerging stock markets, to explore the volatility of oil prices. Mainly, the study period from 1992-2005 has been explored to incorporate the daily data, covering 3348 observations in emerging countries' stock markets. They came up with a conclusion that volatility in oil price exert a negative influence on aggregate equity returns. Moreover, another evidence of linkage between fluctuations of prices for oil asset and returns in equity market is determined by Hammoudeh & Choi (2007). This study applies Markov switching model developed by Kim (1993) and Kim and Kim (1996) to capture the oil price uncertainty. The impact of oil shock has been analyzed in Gulf council countries markets based on weekly data for a sample period from 1994 to 2004. The important insight of this study is the inclusion of the Iraq war 2003, the terrorist on United States in 2001, crisis in East Asia 1997 and the 1998 as well as 1999 oil prices. They also incorporated the volatility regime switching effects of oil price shocks during the entire period of study. The oil prices show a strong correlation for two countries namely, Saudi Arabia and Kuwait. Lastly, they found maximum returns during high volatility regime.

The oil price risk and its impact on stock markets have been studied in Australia by Faff & Brailsford (1999). This research applies two factors model by dividing the whole sample time into two sub periods such as 1983-1989 and 1989-1996 on the basis of monthly data. Generally, the study concludes that oil prices significantly influence the industries cost where oil is used as an input factor. Furthermore, in some industries, oil prices have a significant positive influence, whereas for some other industries the effect is negative. Lastly, a negative effect of oil prices was also observed in banking sector through the interpretation of misspecification of model and negative sensitivity of oil prices shocks was found in paper and packaging industry as well as in transport industries.

Papapetrou (2001) examined the oil price volatility and stock market relation in Greece by using the same approach as Jones & Kaul (1996). By applying the multivariate vector auto-regression model, variables such as economic activity, oil prices, stock returns, interest rate and employment are tested during 1986 to 1999 on monthly data. This study drew a conclusion that oil prices affect the output, growth and real economic activity. Moreover, stock market in Greece is also influenced by changes in oil prices during analysis time period. Furthermore, interest rates in the country and employment are negatively correlated which suggests that an increase in interest rate is linked with lower production and unemployment. Finally, the stock market is found to be negatively correlated with oil price shocks as oil price movements determined stock market returns.

Further, one of the important studies, conducted in United States and Japan by Horng and Wang (2008), applied alternative methods, dynamic conditional correlation and bivariate asymmetric GARCH models to capture the impact of oil price changes on stock markets under negative and positive dimensions of oil shocks on stock returns. Three variables, oil prices, Japanese stock prices and US stock market prices were used to draw the significant results in literature throughout sample period from 2000 to 2006. However, they found that Japanese stock market and US market have shown asymmetric effects throughout the study period. Further, the study shows that both stock markets observe a negative impact of oil price shocks. Hammoudeh and Li (2005) tested the oil related economies such as Mexico and Norway with oil and transport industries in United States, to investigate the oil price volatility relation between oil prices shocks and stock markets during the study sample period. The study used daily data from 1986 to 2003 and posits a negative relationship between oil prices and US transport industry.

Next, a study in the context of impact of oil price changes and stock market was conducted by McSweeney and Worthington (2008) for Australia. The study investigated the monthly data from 1980 to 2006 at industrial level namely insurance, energy, banking, media, property trust, material, financials, transport and retailing. In addition, they also tested the other variables i.e. industry returns, exchange rate, oil prices and market returns. They came up with conclusion that stock returns in banking, retails and transport industries were negatively influenced as a result of increase in oil prices. Furthermore, Driesprong, Jacobsen, and Maat (2008), for the first time used a sample of developed and emerging markets, to analyze the oil price movements and their impact on returns by using monthly data from 1973 to 2003. They drew a conclusion that oil price reacted negatively to returns in stock markets.

The above mentioned impact of oil prices and stock market returns is also documented by Chiou and Lee (2009) in United States stock market using autoregressive conditional jump intensity model. The study verifies the significant impact of oil volatility on Standard & Poor 500 index returns. The important insight of the study is the recognition of asymmetric impact of oil price changes on stock market. Their main findings suggest that stock market responded negatively towards oil price volatility. Specifically, after considering the autoregressive jump intensity model, results explained a significant asymmetric impact on returns as a result of higher fluctuations in oil prices.

Billmeier and Massa (2007) take the case of selected emerging Middle East and Central Asian countries to analyze the same question. Precisely, the study takes the panel of oil importing countries such as Pakistan, Morocca, Tunisia, Georgia, Jordan, Lebanon, Armenia, Kyrgyz Republic and oil exporting countries such as Iran, Oman, Saudi Arabia, Qatar, Egypt, Bahrain, United Arab Emirates, Kuwait and Kazakhstan over the period from 1995 to 2005. They used fixed effect panel regression model, which included stock traded, remittances, inflation change, oil price index, domestic credit, oil income and investment and shows that stock returns are positively influenced by increase in oil prices for oil exporting countries, whereas increase in oil prices had a negative influence on stock market in oil importing countries.

Apergis and Miller (2009) applied vector autoregressive model for eight developed nations such as Canada, France, Germany, Japan, Australia, Italy, US and UK covering the time span from 1981 to 2007. The VAR model was applied on monthly data for crude oil price, real economic activity, and stock prices of concerned countries, crude oil production and consumer price index for the study period. Particularly, the oil price shocks were further divided into oil supply, aggregate oil demand and global oil demand shocks, respectively. However, the study contributed to the main results in the existing literature, by first, showing that stock markets responded differently towards oil supply and oil demand shocks. Secondly, the stock markets responded negatively to idiosyncratic oil demand shocks. Another important contribution in this literature was by Malik and Ewing (2009) on sectoral stocks including financial, health, technology, industrial and consumer services to investigate the oil price volatility for the period of 1992 to 2008. The GARCH model applied on weekly oil prices and sector stocks data for investigating the influence of oil shocks in the US. They found that oil price shocks have a varying impact on different stocks at sector level.

El-Sharif, Brown, Burton, Nixon, & Russell (2005) examined the stock market in UK and oil prices volatility transmission during the study time from 1989 to 2001. They incorporated a daily data comprising oil prices, stock prices of oil and gas sector in multifactor model. Therefore, the important insight of the study was to compare four sectors, the mining, the banking, the transport and the computer sector against oil price shocks in two factor models. Furthermore, the study came up with important findings that linkage between rise in oil and oil related sectors' prices were positive, while non-oil related sectors stock returns showed low correlation as a result of increase in oil price in UK. Similarly, crude oil price influenced negatively on non-oil and gas related sectors.

Depending on the structure of different countries, many previous studies provided different findings in relation to impact of oil shocks on stock markets. For instance, Guntner (2014) tested the response of international markets towards oil shocks in net oil importing and net oil exporting countries covering the sample from 1947 to 2011. They applied the same model i.e. structural vector auto-regression, which was previously used by Kilian and Park (2009) in their study, on worldwide oil production, stock markets returns with respect to oil importing and oil exporting countries, world real economic activity, oil price especially related to each country. Interestingly, this study divided the oil shocks into oil supply, aggregate oil demand and oil demand shocks to draw the conclusion. The study found that shortfall in oil supply on global level has insignificant impact in all countries. Whereas, the demand oil shock contributed a significant impact especially in oil exporting countries. Finally, negative response of oil supply shocks has been observed towards real stock returns.

Later on, many researchers support the previous studies by investigating the oil price dynamics on different countries stock markets. However, Ciner (2013) tested the relationship between oil price and stocks using monthly US stock market indices for time span 1986-2010. This study incorporated the dependent frequency regression model between oil prices and stock prices. Furthermore, results suggested that oil price changes in less than one year would negatively impact stock returns. Further, Asteriou and Bashamakova (2013) confirmed the impact of oil price risk in Eastern and central European economies on the basis of panel data from 1999 to 2007. They came up with an interesting finding that stock markets returns showed a negative response as a result of changes in oil prices.

Similarly, Abhyanker (2013) analyzed the Japanese stock market in relation to oil price volatility. The author incorporated the structural VAR model on monthly data from sample period 1988-2009. However, an adverse impact of volatility in oil prices have been originated on stock returns in Japan. Filis and Chatziantoniou (2014) examined oil price shocks and stock markets in oil exporting countries and importing economies. They used similar model applied earlier by Abhyanker (2013) for each country on monthly data from 1991-2010 to capture the response of four variables consumer price index, oil prices, stock market return in oil importing and exporting countries and interest rate. In addition, the study reconfirmed that stock markets responded negatively towards rise in oil prices for oil importing countries. Ansar and Asghar (2013) established a weak positive linkage among oil prices, consumer price index and stock market index for Pakistan. Furthermore, Najaf *et al.* (2016) documented a negative relation among stock market, oil and gold market over the period 1996 to 2013. At sectoral level, Huang *et al.* (2015) documented the impact of oil changes on stock market in China covering ten sectors stock data on daily basis from 2005-2013. Based on wavelet approach, the study shows that sectoral stocks' indices negatively responded towards oil shock in the short run.

2.1.2 The Positive Impact of Oil Price Shocks and Stock Markets

Theoretically, there is a significant influence of rise in oil prices on equity markets in oil exporting economies because of income effect. As a result of rise in earnings, it is expected to rise in investment and expenditures, which in turn increases the employment rate and output or productivity. Accordingly, stock markets respond positively because of increase in corporate earnings. In literature, numerous empirical studies reconfirmed this indirect impact of oil shocks on different countries. For example, Arouri and Rault (2012) examined the impact of oil price on equities in oil exporting economies during 1996-2007. In-addition, panel cointegration technique applied on monthly frequencies during the study period. They concluded that there is a positive influence of prices volatility oil in most of the oil exporting countries. At industrial level, Li *et al.* (2012) explored the stock markets in China from 2001 to 2010 by incorporating the panel cointegration technique on monthly observations. The study concluded that price volatility of oil put forth a positive effect on returns in equity market for long time. The impact of oil price shocks on stock returns at sector level between 1983 to 2005 sample time span, explored by Nandha & Faff (2008). This study concluded that, out of 35 sectors, only oil and gas sector is positively influenced by an increase in oil prices.

Kilian and Park (2009) conducted a study in United States on monthly data collected from sample period 1973-2006, to order to scrutinize the volatility in prices of oil and returns in aggregate stock market. However, the stock market responded differently towards oil volatility as a result of oil supply, demand shocks by oil market specific and global demand shocks. They concluded that fluctuation in price of oil driven by global demand shocks had a considerable positive influence on returns on aggregate equity market for US economy. Filis *et al.* (2011) studied the relationship among price volatility of oil and equities for economies importing and exporting oil. They disclosed that financial markets responded to increases in oil prices in positive manner originated by demand side shocks.

Cunado and de Gracia (2014) contributed an interesting study in literature. They investigated the impact of oil price uncertainty by using local oil prices for the sample of twelve European economies from 1993 to 2011, they interpreted that oil price shocks originated through oil demand shock, responded positively to financial markets only in Denmark and France. Park and Ratti (2008) tested the performance of movements of prices of oil on financial market in United States and other European economies. They analyzed the monthly data comprising the sample period from 1986 to 2005 by investigating the variables namely oil prices, stock returns, consumer price, industrial production and interest rate. In addition, they applied VAR model to explain the behavior of these variables. Moreover, the study found only a positive performance of price volatility of oil asset on returns for financial market in Norway. Caporale *et al*. (2014) recorded weekly oil price data to evaluate the performance price volatility of oil on ten Chinese sectoral equity indices. The study utilized the data from 1997 to 2014 by employing the bivariate GARCH model. They concluded a considerable influence of oil demand side volatilities only on stocks related to energy sector.

The study of El-Sharif *et al.* (2005), investigated the financial market in United Kingdom regarding volatility transmission of oil prices. The study tested oil and gas sector for the sample of large oil producer in the European Union and United Kingdom during 1989- 2001. The study came up with important findings that stock markets positively influenced by oil shocks driven from demand side. Faff and Brailsford (1999) explored the Australian market to examine the behavior of oil price volatility. They used two factors model on monthly data collected from 1983 to 1996 on stocks at industrial level. The results of the study indicated that only two industrial stocks such as oil and gas and diversified resource industries were affected by oil price changes in a positive manner. Similar results were produced by Boyer and Filion (2007) oil and gas companies in Canada by incorporating the interest rates and exchange rates as independent variables.

Other numerous authors also analyzed the Chinese stock market for oil price volatility behavior. For example, Broadstock *et al.* (2012) examined the oil price volatility and its impact on energy related stocks for weekly frequencies from 2000 to 2011. By applying time invariant conditional correlation and assets pricing models, this study concluded an optimistic influence of changes in prices of oil on returns for equities related to energy sector but this relation was stronger particularly after the turbulence time period 2008-2009. Similarly, Peersman and Van Robays (2012) scrutinize the performance of price volatility of oil in financial markets for economies importing and exporting oil. For economies exporting oil, they found that a permanent rise in economic activity was due to an optimistic performance of oil supply shocks on returns in equity markets.

Gogineni (2008) studied the behavior of financial markets towards oil price volatility during the sample time from 1983 to 2006. In addition, this study divided the oil shocks into small and large oil price changes. Finally, the study concluded that returns in equity markets are optimistically affected by small changes in price for oil asset. Further, Eryigit (2009) studies the oil price changes and their impact on sector stock indices in Turkey. This study applied OLS techniques on monthly data collected from Istanbul financial market during the sample time from 2000 to 2008. This study revealed that price volatility of oil asset exerts an optimistic impact on equity returns in some sectors such as Paper and Printings, Wood, Insurance and Electric sectors. For Pakistan, a positive linkage has established by Siddiqui (2014) between prices oil commodity and equity market for the study period from 2003 to 2012. Further, Irshad *et al.* (2012) concluded that no long-term relation exists among alternative assets and the equity market for time span 2002 to 2010 in Pakistan.

2.2 Gold Characteristics

2.2.1 Gold Performance as a Best Portfolio Diversifier

Does gold act as a best diversifier asset in portfolio? Many previous authors provided the answer of this question in the literature. For instance, McDonald and Solnik (1977) were among the pioneers to study the gold's feature to act as a risk diversifier asset in a traditional portfolio of stocks. They found that gold acts as a best diversifier in the portfolio and maintained a positive relation during the sample period from 1948 to 1975 by incorporating two-factor model for gold and gold mining stocks. Further, Jaffe (1989) provided the evidence that, when gold is added in the traditional portfolio, it acts as a best diversifier but individually, gold is a risky asset. Using the monthly data from 1971 to 1987, he found that gold maintained weak correlation with other assets when included in portfolio and provided a diversification opportunity to managers and investors.

Chua, Sick, and Woodward (1990) applied the capital assets pricing model from 1971 to 1988 on monthly data and reconfirmed that gold has a low beta value which insignificantly differs from zero during time varying periods. In addition, increase and decrease in price of gold had no relation with prices of stocks during the period of the study which confirmed the characteristic of gold as hedge asset against risk of portfolio. Finally, the beta for gold stocks varies as compared to gold asset beta which is stable; this explains that gold stock provides poor diversification opportunity in a portfolio. Contrary, Hiller, Draper, and Faff (2006) tested function of three commodities gold, platinum and silver in financial markets for assets allocation from 1976 to 2004. Their study came up with an important finding that gold, platinum and silver suggested portfolio diversification benefits when added to US portfolio in a speculative market, whereas diversification benefits of all commodities were narrow during crisis time in the market. Finally, these commodities have a negative correlation with Standard and Poor 500 Index. Lucy, Poti, and Tully (2006) examined the mean-variance skewness approach during the sample period from 1988 to 2003 instead of using only mean and variance analysis for the construction of optimal portfolio. They suggested that gold offer a diversifying prospect in optimal portfolio because of negative correlation with stock market during the study time. Johnson and Soenen (1997) examined the feature of gold asset for investment prospective in different countries from sample period of 1978 to 1995. They established that gold provided the diversification benefits when gold performance measured through risk and return trade off while gold performance was weak when measured as risk adjusted return during the period of the study. Further, Conover *et al.* (2009) studied the effectiveness of gold and suggested that gold offer the diversification prospect when added in stocks' portfolio than other commodities i.e. platinum and silver. This study concluded that indirect investment in gold provides a better portfolio diversification.

In addition, portfolio implication of gold has been tested by Ratner and Klein (2008) during the sample period from 1975 to 2005 in United States' equity sector. The study found that gold provides the poor investment just to buy and hold for long time. More importantly, they demonstrated that gold provided the benefits of diversification in portfolio in the long run when 5 percent optimal weight of gold is added in international portfolio. Recently, Emmrich and McGroarty (2013) extended the work of Jaffe (1989) from sample period 1981-2011 by studying the role of gold in an institutional portfolio. The study reconfirmed the Jaffe's (1989) results that gold provided diversification benefits in portfolio of stocks during certain times. In 1980s and 1990s, gold suggested the weak returns. However, equity and gold correlation was found to be low which suggests that gold has its importance in reducing the risk of portfolio and increasing the returns.

2.2.2 Gold Performance as Safe Haven

Baur and Lucy (2010) tested the properties of gold as hedge or safe haven against stocks and bonds in US, UK and Germany, by taking the sample period of ten years from 1995 to 2005. Theoretically, they documented that safe haven is an asset which is uncorrelated with another asset in portfolio during the financial crisis in the market while hedge is an asset that is negatively correlated with another asset on average. However, they found that gold has characteristics of safe haven only for stocks during the bad times in stock market. The study also suggested that gold acts as a safe haven only for fifteen days but not for a longer time and investors could hold gold only for 15 days and then sell it when stock market is less volatile. By contrast, Bredin, Conlon, and Poti (2015) analyzed the same markets from 1980 to 2013 by incorporating the Wavelet approach. They concluded different results from Baur and Lucy (2010) that gold maintained its attribute as safe haven asset for one year at the turbulence period in financial market.

Similarly, Baur and McDermott (2010) reconfirm the property of gold as a safe haven asset by investigating the international markets from 1979 to 2009. Their findings acknowledged that gold has a status of safe haven asset in some countries. In more details, gold acts as a safe haven asset in Germany, Italy, United States, UK, Japan, France and Switzerland during the crisis time in market. Theoretically, in finance, the gold investment rises when investment in financial assets drop during financial crisis. Cohen and Qadan (2010) investigated that gold data and VIX index during the period from 2004 to 2009 and found that gold acts as safe haven against financial assets during bad times. Further, they found a bi-directional causality between gold and VIX index in normal conditions. Hood and Malik (2013) used similar approach to Baur and McDermott (2010) during the time span from 1995 to 2010 to examine if gold acts as hedge or safe haven during financial crisis in stock market? They elaborated that gold has a status of safe haven during the study period and because negatively correlation is originated with stock markets based on GARCH model.

Interestingly, Ghazali, Lean, and Bahari (2015) investigated the property of gold with Islamic principal investment being a safe haven asset in Malaysia by applying the daily data from 2010 to 2014. They argued that an Islamic gold account does not provide the benefit as a safe haven asset during turbulence time in the financial market. On contrary, Gurgun and Unalmis (2014) investigated the emerging countries and less developed countries. However, the gold acts as a safe haven and hedge for local investor in many economies. On the other hand, gold has a status of only safe haven for foreign investors in few economies. The study conducted by Ibrahim (2012) in Malaysia from 2001 to 2010 on daily frequencies. The study suggests that gold maintains negative association with equity market. Finally, gold has features of hedge during bad times in stock market.

Some previous studies also noticed that not only gold has features of safe haven but silver also provides the benefits of a safe haven. Lucey and Li (2015) tested the property of gold, silver, platinum and palladium as a safe haven in United States during the sample period 1989-2013. They provided interesting results which differ from earlier studies that silver, platinum and palladium have features of safe haven assets in third quarter of 1996 when gold was acting as a safe haven. They suggested that silver acts as a stronger status of safe haven asset against decline in stock market and documented the risk hedging benefits in portfolio management by adding silver in traditional portfolio.

Choudhry, Hassan, and Shabi (2015) pointed similar results in US, Japan and UK by incorporating the gold returns, stock returns and volatility in stock markets during turbulence time period. They divided the sample period into sub-samples i.e. pre-crisis period 2002-2007 and crisis time 2007-2014.Furthermore, the results depict that gold had lost its status of being a safe haven asset during crisis in financial market as there were bi-directional relation among stock returns, changes in stock returns and gold returns, whereas gold acted as a safe haven before financial crisis. Finally, the study found the status of gold as hedge asset when conditions in financial markets are better.

Joy (2011), using DCC-GARCH model, takes the question of whether gold acts as hedge or safe haven against United States dollar? The study concluded that gold has lost its safe haven asset features for stress period in equity market. Likewise, Ciner, Joets, and Mignon (2013) conducted a research to explain the status of gold as hedge or safe haven against United States dollar, United Kingdom pound, stocks, bonds and oil commodity by applying Joy (2011) model. They found that gold has been regarded as a safe haven in both economies for US dollar and United Kingdom pound showing that gold can be considered as monetary asset in financial market. Finally, the study documented that gold maintained the safe haven ability against severe movements in oil prices; same results were contributed by Reboredo (2013b).

Soytas *et al.* (2009) analyzed the ability of gold in Turkey denominated in local currency in relation to locally exchange rate. They found that exchange rate is negatively correlated with local gold prices in Turkey illustrating that gold maintains an ability of safe haven asset. More specifically, gold acts as a safe haven asset during the depreciation of Turkish lira. Theoretically, the status of gold has been reduced as a safe haven asset because of more and more gold investment just for speculative purpose based on investor’s behavior. Further, empirical results concluded that time of safe haven had trimmed down during the financial crisis because gold value suffered in the same manner as other assets in stock market.

2.2.3 Gold and Other Currencies

Several researchers claim a negative relation between gold and US dollar. In fact this relation to gold price and other currencies such as US dollar attracted the interest of policy makers, international portfolio managers for risk management against movements in currency around the world. In addition, the trading activities of gold are also denominated in US Dollar. It has been regularly discussed that gold price increases as a result of depreciation in US dollar, which provided the evidence of gold’s status as hedge in relation to movements in currency and as a safe haven asset against severe movements in currency in financial markets. In literature, Pukthuanthong and Roll (2011) documented the role of gold’s price with currencies of other countries. They argued that gold price is linked with devaluation in currency of other countries.

Further, Soytas *et al.* (2009) studied the ability of gold in Turkey denominated in local currency-in relation to local exchange rate. They found that exchange rate is negatively correlated to local gold price in Turkey and documented that gold maintained the ability of safe haven asset. More specifically, gold acts as a safe haven asset during the depreciation of Turkish lira. Wang and Lee (2011) investigated the gold's relation to yen in Japan during 1986 to 2007 and found that gold provided the hedge benefits for Japanese yen during the period of the study. Sjaastad and Scacciavillani (1996) studied the relationship between exchange rate and worldwide traded commodities. They found that changes in gold price depended on instability in exchange rate. Further, the impact of instability in US dollar was also transmitted to gold price. Similarly, the results of Sjaastad (2008) verify the relationship between exchange rate and globally traded commodities.

Capie, Mills, and Wood (2005) used weekly data and examined the ability of gold as hedge against exchange rate from the study period 1971-2004. The study reports an inverse correlation between dollar and gold price. Secondly, gold has shown a hedging status against increase and decrease in United States dollar exchange rate. However, O'Conner and Lucey (2012) elaborated that gold price is linked with other currencies through negative correlation. The gold denominated in local currencies and similar relation was found with Australian dollar, Japanese yen and Canada currency. Theoretically, when dollar is depreciated against all the other currencies, it also got depreciated against gold. Further, gold is considered as a currency, its value increased against US dollar, when currencies such as Australian dollar, Japanese yen and Canada currency increased in the world.

2.2.4 Gold Ability as Inflation Hedge

Theoretically, Fisher (1930) developed a relationship between inflation and interest rate, which provided the foundation of relation between gold and inflation. The results concluded that, when estimated general price level increases, the projected price of asset also increases. Further, Fama and Schwert (1977) worked an empirical test using government bills and bonds data, property prices, income of labor, and returns of stocks in the United States. Theoretically, Feldstein (1980) drew a relation between inflation, land and gold values. The results of the study suggested that gold and inflation are linked with each other because gold is considered as legal tender money as United States dollar and values of gold could not decrease through sharp increase in supply of fiat money e.g. Euro and United States dollar. This study pointed out that rise in projected increase in general price level led to increase in nominal rate of interest. For risk averse investors, the study indicated that price of gold rises due to increase in desired rate of return on gold, to indemnify a rise in opportunity cost.

Accordingly, Fortune (1988) clearly elaborated the inflation and gold prices through substitution effect. The author developed the model on quarterly observations during the time span from 1973 to 1980. The results suggested that people would transfer their current investment which comprises of fixed nominal rate of return into gold when expected general price level increases. The study revealed that a positive linkage between price of gold and inflation. Similarly, Ghosh *et al.* (2004) used the approach as developed by Fama and Schwert (1977) and found that gold maintained ability of hedge against general price level for a long-time period. The study found that an upward trend in general level price undermine the value of financial assets such as stocks. For investors, inflation risk is the most serious issue in developing countries. Under such situations, investors and portfolio managers shift their investment to safe haven assets in order to minimize risk and prefer those financial assets which held their worth during the inflationary pressure. Traditionally, investment in physical assets like gold and silver are recognized as effective safe haven alternative assets and strong hedge assets against inflation. However, Gold is considered as hedge against inflation because gold maintains its value during recession period.

Levin, Montagnoli and Wright (2006) documented a relationship between inflation and gold price on monthly frequencies using a different model which was constructed through arbitrage approach given by the Levin, Abhyankar, & Ghosh (1994). The findings of study showed that inflation rate lead to movement in cost of gold production. As a result, gold prices had increased to pay-off the miners due to their rising cost of gold production in the long-run. In addition, fundamental linkage existed between cost of gold extraction and inflation. Further, the study found that mining persons would not act as price takers. Blose and Shieh (1995) and Borenstein and Farrell (2007) came up with the opposite result that gold mining people act as price taker, not as a price setter. Rockoff (1984) analyzed the linkage among cost of gold extraction, actual price of gold and price of commodities. The results of study argued that production cost of gold is considered as a key reason which determines real gold price level.

In literature, many authors analyzed the hypothesis of whether there is any relationship between gold and inflation in the long-run and short-run? For this purpose, Taylor (1988) examined the long run and short run relationship among gold, silver, platinum and consumer price index on monthly data during the time ranging from 1914 to 1937 and 1968 to 1996. The selected sample was divided into two sub-sample such as post-war period from 1968 to 1996 and pre-world war period from 1914 to 1937. The study applied the Johansen cointegration approach for long run analysis among the variables. Finally, precious metals and inflation established stable relation during 1968 to 1996 and 1914 to 1937. McCrown and Zammerman (2006) verify these results and argued that, gold maintains its status against general price level only in higher inflationary pressure times. Tkacz (2007) extended the range of economies and added fourteen countries from 1994 to 2005 on monthly frequencies. The results of study suggested contradictory outcomes for inflation target countries, OECD and Non-OECD economies. Finally, general price level predicted the gold price in many countries. Ranson and Wainright (2005) explored similar research by adding the oil characteristic as a driver of inflation in United States and United Kingdom. The study came up with new findings that oil did not have ability of main driver of inflation in both countries. On the other hand, gold and inflation maintained positive correlation in United States and United Kingdom. Further, the study also pointed that price of gold was two-three time greater than general price level. Finally, the study concluded that gold maintained its status as hedge against inflation in such economies. Moore (1990) tested the gold property as hedge relative to general price level which found that gold offered hedge ability against inflation in long as well as in short period.

Levin *et al.* (1994) documented a long and short run relationship between gold price and inflation. The results of the study indicate equal linkage between gold and inflation. Furthermore, gold maintained a status of hedge asset against inflation in the long run. Next, Levin *et al.* (2006) worked on key determinant of gold for short and long-run using the monthly data from 1976 to 2005. The study uses cointegration technique and finds that, inflation and gold price are positively correlated in the long-run. Further, a 1% increase in inflation in USA yields 1% rise in gold price in the long run. This is one to one relation between general price level and gold price in United States, showed that gold, preserved the status to hedge against inflation. However, short term relation existed in the presence of other factors such as exchange rate in United States dollar, credit risk, general price level rate, changes in inflation and leasing gold rate.

Gold is considered as hedge tool against inflationary pressure around the world. Furthermore, a rise in gold prices is due to rise in inflation; similarly, changes in gold prices indicate the inflation stress. However, the ability of gold as hedge against general price level is not as important as is the question of; how well gold maintained its status as hedge asset? Every country in the world has its own financial circumstances and uniqueness. For this purpose, many regions based studies can be found in the literature. For example, Worthington and Pahlavani (2007) tested the gold status as hedge against inflation by expanding US sample data from 1945 to 2006. They applied modified cointegration approach on monthly data with structural breaks by dividing the whole sample into two sub-samples i.e. from 1945 to 2006 and from 1973 to 2006. The study showed that gold has the ability to hedge against general price level with one to one relationship between gold and inflation.

Batten, Ciner and Lucey (2014a) analyzed the relationship between gold price and consumer price index, covering the monthly frequencies during the time span 1985-2012 for the US. The important insight of the study was to analyze the data after 1984 because of existence of structural break in general price level in United States during 1984, at the start of great moderation as mentioned by Stock and Watson (2007) and Atkeson and Ohanian (2001) in their studies. However, the study found that gold acts as hedge against inflation.

Le Long *et al.* (2013) investigated gold's characteristic as hedge against inflation in Vietnam by taking monthly data from 2001 to 2011. They found that gold retained its ability of hedge against inflation during the period of the study. Another important contribution made by Omag (2012), reporting gold property as hedge against increasing inflation in Turkey. This research applied regression model, using interest rate, exchange rate, prices of gold, inflation and Istanbul stock exchange prices as covariates, for sample period from 2002 to 2011. The study reconfirmed that gold prices are positively influenced by increase in general price level driven by nominal interest rate in the country which showed that gold acts as hedge against inflation in Turkey. Blose (2010) while investigating the ability of gold against inflation provided contradictory results. The important insight of this study was the use of two hypotheses such as inflation hypothesis and carrying cost hypothesis. The main finding of the study indicated that the movements in general price level lead to changes in gold prices. In addition, a large change in general price level also directed to large movements in interest rate. Finally, gold price is not affected by inflation and vice versa.

Similar, Shahbaz *et al.* (2014) analyzed the hedging ability of gold against inflation in Pakistan, by taking monthly data during 1997 to 2011 for short and long time. The study came up with an interesting finding that, for long time, a 1% rise in general price level directed 1.9 % rise in price of gold and gold prices are also positively influenced by inflation. While in the short time span, gold prices get negatively influenced by growth factor in Pakistan, indicated that gold is not a better hedge against inflation. Finally, they found that gold maintains its ability as hedge against general price level for long time in Pakistan. Bampinas and Panagiotidis (2015) examined the ability of gold and silver as hedge against inflation in United

States and United Kingdom on large data set which collected for time span from 1791 to 2010. Based on twelve month observation, they found that gold maintain its hedging status against increase in the long-run general price level.

2.2.5 Gold and Investment

A sharp increase in investment of commodities has been observed since the last decade. During 2009, commodity's investment recorded to be about sixty billion dollar (Wall Street Journal), which is projected to increase in future. A large interest of investors to invest in commodities shows that commodities are alternative financial assets which show a negative relation with traditional assets class such as stock and bonds during financial crisis. It means that the factors which determine the price of commodities are different from those which decide the price of other financial assets like stocks (Geman, 2005). Further, commodities maintained their status against inflation as compared to bonds and stocks (Bodie, 1983). However, gold has distinctive characteristics among all other financial assets. The price of gold has remained a debatable issue since gold price is assumed to be determined keeping in view the macroeconomic policies.

Machlup (1969) is among the first to study investment of gold after former United State President Nixon's 1971's decision to close the gold's window by presenting an economic policy to convert the dollar currency into gold standard. This study also advanced the idea of speculation and indicated that speculator could purchase an asset today with a view that price will increase tomorrow. Further, the author provided the benefit of investment in gold as compared to other financial assets. In fact during 1969, gold observed the 35 dollar value which could not be retained without government intervention. As a result, the value reduced as gold reserve decreased due to sale of gold. However, gold prices increased more or less two hundred points in the next three years, which rejected any involvement of government for settlement of gold prices. Gold prices remained stable in 1971, but increased after 1971 as general price level increased constantly. This raises a question of whether has the sharp increase in gold price followed inflation?

2.2.6 Gold and Other Valuable Metals

"Everything else is credit. Gold and Silver are money." *J. P. Morgan*

Historically, gold and silver are close substitutes and used as a currency. Both commodities play an important role in portfolio diversification for risk minimization and also considered as a useful investment (Sherman, 1982; Landa & Irwin, 1987; Aggarwal & Sonen, 1988; Johnson & Soenen, 1997; Peters & Egan, 2001; and Adrangi, Chatrath, & Raffiee, 2003). Furthermore, silver is mostly a useable commodity for industrial purpose as compared to gold which is considered valuable for jewelry purpose as well as for reserve maintained by the central banks. However, gold was considered as a monetary commodity in most economies between eighteen and nineteen centuries because of huge rise in supply of gold and silver. However, macroeconomic variables determine the gold and silver prices in a similar way (Dooley, Isard, & Taylor, 1995; Christie-David, Chaudhry, & Koch, 2000). Moreover, trading activities would likely to take place in both commodities simultaneously by many investors.

In previous studies, many authors studied the relationship between gold and silver. For instance, Ma (1985) worked on gold prices and silver prices which connected equally through long term percentage values. Historically, the ratio of gold and silver showed one to one relation during earliest Egyptian times. This ratio has changed during 2000 and placed new ratios such as 13.5:1 and 16:1 by Congress (United States) until 1837. This study also found one to one short-term relation between gold price and silver price from 1978 to 1983. Finally, investors earned above average profits before incorporating the transaction cost. Wahab, Cohn, and Lashgari (1994) confirmed the above findings and concluded that a one to one long-term relation existed between gold spread and silver spread on daily observations during 1982 to 1992. The study also revealed that positive profit could not be generated after inclusion of cost of trading. Koutsoyiannis (1983) used daily data from 1980 to 1981 by including other independent variables like nominal interest rate and political tension. The study highlighted that these variables were unable to predict the gold prices. In short, the study suggested that, it is imperative to re-define the relation between gold and silver. Finally, price of silver could not be used to define the price of gold. In contrast, Luke, Chan, and Mountain (1988) analyzed the causal linkage between silver and gold values' changes using weekly based observations and found that a causal relation existed between both commodities' prices.

Moreover, silver and gold do not belong to the same group because both commodities have their own peculiar features. Different empirical studies highlighted differences between both commodities prices. Escribano and Granger (1998) analyzed the relationship between gold and silver using monthly observations from 1971 to 1990. The entire study time has been distributed into sub-sample such as 1981-1990 and 1990-1994. The results of the study pointed contradictory findings during sub-samples. They argued that long term relation existed between gold returns and silver in out-of-sample period 1990-1994; weak relation existed between gold and silver markets which suggested that gold and silver markets performed differently in comparsion to each other. Ciner (2001) used daily frequencies and tested the long range cointegration between silver and gold prices which were traded during the sample time from 1992 to 1998. The results contradicted with those of Escribano and

Granger (1998) indicating that short time relation existed between both commodities. In addition, silver and gold ratios were incapable to estimate future prices of both commodities. Lucey and Tully (2006) analyzed the relationship between same commodities, by extending the time horizon over twenty four years. The study used cointegration approach to analyze the daily frequencies of gold and silver commodities.

Further, Adrangi, Chatrath, and David (2000) documented the price discovery process and linkage between gold and silver prices during two year sample period from 1993 to 1995. The study finds that silver price move on average over the time. Further, the study also indicated that movements in gold and silver spreads explained the volatility in silver market. However, Chatrath, Adrangi, and Shank (2001), using ARCH model, provided an evidence that gold and silver future contracts are linked through indirect dependency for their sample period of 1975 to 1995. Liu and Chou (2003) studied the parities and spreads in gold and silver markets for futures and cash prices for time span ranging from 1983 to 1995. By applying fractional cointegration approach, they found that future and cash spreads of gold and silver indicated long term relation.

Contrary, Kearney and Lombra (2009) examined the relationship between platinum and gold commodities over the period of 1985 to 2006. The results of the study indicated a positive association between gold and platinum in the long-run and a negative linkage in the short-run between 1996 and 2006. Further, Chng and Foster (2012) extended the research in the similar context by adding four precious metals such as gold, silver, platinum and palladium on daily data, covering the time period from 1996 to 2010. They found that gold and silver are regarded as leading commodities over platinum and palladium and returns of these commodities are affected by gold and silver yields. Finally, other two commodities' yields were unable to predict returns of gold and silver.

Batten *et al.* (2010) studied the volatility relationship among gold, silver, platinum and palladium and examined the effect of macroeconomic variables in United States. They found that changes in gold prices are affected by financial variables and silver price is less effective in predicting the gold prices. Next, Batten *et al.* (2014b) argued on spillover relationship among four metals including gold and found a significant spillover effect between gold and silver. However, palladium and platinum were recognized as a separate market class as compared to gold and silver markets.

2.3 Gold and Stock Markets

Traditionally, investors always try to buy financial assets at a lower price and sell them at a higher price in stock markets. For investment purpose, they secure their money by investing in those assets which are less volatile like gold during financial crisis as compared to highly volatile assets such as stocks and bonds. However, various researchers examined the relationship between gold and stock prices or returns by incorporating different models, countries and time span in their studies. For example, Jaffe (1989) found that gold returns and equity returns had rendered negative correlations. Furthermore, Moore (1990) studied the movements of gold and stock prices as per signals generated by inflation during 1970-1988. This study established a negative relation between gold and stock prices by incorporating the inflation during the study period. This means that when price of gold increases then stock market starts falling. Smith (2002) studied the relationship between gold prices and stock prices for the sample period from 1991 to 2001 by applying daily, weekly and monthly frequencies. The findings of the study showed a negative association between gold returns and stock returns during the study period. Buyuksalvarci (2010) confirms these results for Turkey in a model that also includes additional variables like interest rate, industrial production, oil prices, money supply and exchange rate.

Further, Baur and Lucy (2010) tested the properties of gold as hedge or safe haven with stock and bond in US, UK and Germany, by taking the sample period of ten years from 1995 to 2005. They concluded that gold and stock market returns in United States showed a negative long term relation while, gold and bond market returns established positive association during the study period. Baur and McDermott (2010) extended the similar hypothesis in developed and emerging countries from 1979 to 2009. This study applied daily, weekly and monthly observations of returns and found that only stock markets of developed countries confirm an inverse relation. Hiller *et al.* (2006) explored gold and stock market relations by adding other two precious metals namely, platinum and silver and tested a behavior of these commodities in financial markets during 1976 to 2004. The study brought to surface an important finding that gold, platinum and silver specified a negative correlation with Standard & Poor Index. Lucy *et al.* (2006) examined the mean-variance skewness approach during the sample period 1988 to 2003. The study found that gold is negatively correlated with stock market during the study time.

Hood and Malik (2013) used similar approach as applied by Baur and McDermott (2010) in their study, during the time span from 1995 to 2010. This study incorporated the GARCH model on gold price with other commodities and volatility index. The results elaborated that gold exerts a status of safe haven asset since it shows a negative correlation with equities in stock market. Ibrahim (2012) conducted a study from 2001 to 2010 on daily frequencies in Malaysia. This study concluded that gold returns are negatively correlated with returns in stock market. Chua *et al.*

(1990) used the capital assets pricing model and reconfirmed that gold indicated a low beta which insignificantly differs from zero. In addition, increase and decrease in price of gold provided no relation with price of stocks in financial market. Emmrich and McGroarty (2013) extended the work of Jaffe (1989) from sample period of 1981-2011 by studying the role of gold in institutional portfolio. The study reconfirmed the Jaffe’s (1989) finding that gold provided the diversification benefits in portfolio of stocks at certain times. The findings of the study confirmed that equity and gold retain low correlation. Coudert and Raymond (2011) included the developed countries in their analysis for gold and financial market indices. The results show an inverse relation between gold price and stock markets in developed countries. Miyazaki and Hamori (2013) extended this relation among gold, stock, bond and foreign exchange markets. Their study was based on daily observations of gold prices of United States and financial market for time span from 2000 to 2011. Based on asymmetric dynamic conditional correlation approach, they concluded that gold and stock were inversely correlated during crisis times. Recently, Gurgun and Unalmis (2014) extended this relationship between gold and stock markets and adding both developing and emerging economies for daily prices. They applied same approach as used by Baur and McDermott (2010), reported that gold and stock markets maintained negative relation in many countries.

In addition, many studies also documented the volatility mechanism between gold and stock market. Likewise, Diebold and Yilmaz (2009) studied the spillover volatility relation among stock, bond and gold market by using spillover index. This study came up with a conclusion of large spillover volatility effect transmitted from stocks to bond market. Furthermore, weak evidence originated between gold and stock markets. This study extended by Sumner, Johnson and Soenen (2010), attempted to test the spillover effect among gold, stock and bond on weekly observations over the time from 1970 to 2009. This study incorporated the econometric model of Diebold and Yilmaz (2009) and found an insignificant impact of spillover volatility of gold transmitted on stock market volatility. The results also suggested that gold can be considered a separate class of asset which maintained negative correlation with stock market. Mensi *et al.* (2013) analyzed the volatility and correlation among stock market and commodity market during the 2000-2011 in the United States. By applying VAR-GARCH approach they found that stock market volatility put forth its effect on gold volatility. Arouri *et al.* (2015) explored the gold and stock market in China to study a spillover effect. They applied same approach as used by Mensi *et al.* (2013) and found that returns in stock market in China affected by a significant price changes in gold market. Mishra, Das, and Mishra, (2010) documented the movement of gold prices and returns in Indian stock market. Monthly frequencies were used on gold and stocks by applying co-integration approach, to examine the long-term linkage among both assets class throughout the sample from 1991 to 2009. The results concluded that gold prices and returns in stock markets co-integrated each other for long-term. Kumar (2014) explored Indian stock market at sector level and gold asset during the time span from 1999 to 2001. Based on volatility model, the study concluded that gold volatility provided spillover effect on volatility of industrial sector's stock returns. Tufail and Batool (2013) suggested that gold prices significantly impact the stock prices in Pakistan. Recently, Khan *et al.* (2016) concluded short-term relationship between gold prices and KSE-100 Index for time span from 1993 to 2014.

2.4 Gold Market and Crude Oil Market

Gold and oil are two key leading commodities in commodity market and a close relation exists between both these markets. The volatility in oil prices shows its impact on gold as well as on other commodities' prices. This shows that only demand and supply side forces are not enough to determine the prices for both commodities. In 2002, gold and crude oil prices started rising more or less at the time of increase in the value US dollar. This trend maintained till the first half of 2008. During the boom period, oil price observed a decrease from 147 per barrel dollar to 30 per barrel dollar. On the other side, gold prices were reduced from 1000 dollar per ounce to around 700 dollar per ounce. Recently, gold and oil prices declined from more than 100 dollar per barrel to 43 dollar per barrel and from 60 dollar per kg to 40 dollar per kg during 2012 to 2014. However, with the worldwide financial improvement, demand in commodity markets increased again and prices of gold and crude oil prices changed their declining tendency and launched fresh rolling phase. However, the relationship between gold and oil prices has been discussed substantially theoretical and empirical literature, which showed indirect linkage between both commodities. Gold price changes may be observed by oil price movements through a number of factors such as inflation, export revenue, interest rate and US dollar movements.

2.4.1 Gold and Oil Price in Inflation Context

First, a few studies found that oil and gold price indicated a positive correlation with inflation. For example, Hooker (2002) and Hunt (2006) argued that changes in general price level depend upon fluctuations in oil prices and a rising trend in oil prices showed a rise in general price level and lastly, gold prices show an upward trend. Consequently, inflation dynamics can very well explain the theoretical association between oil and gold prices. Abken (1980) documented a positive correlation between gold and inflation in oil prices context. Simakova (2011) studied the linkage between oil price and gold by incorporating supplementary variables such as interest rate, inflation, growth and stock prices of gold mining companies during the study period from 1970 to 2010. This study concluded that a strong relationship existed between both commodities through these common dynamics. Further, Narayan *et al.* (2010) explained conceptual structure of both commodities through incorporation of general price level for the daily data set over 1995 to 2009 for United States. Based on cointegration approach, the study drew a conclusion that increases in oil prices showed the inflation which consequently caused high gold prices. Finally, oil market used to determine the gold price and gold market explained the oil prices. The study conducted by Zhang and Wei (2010) documented the gold and crude oil market connection through inflation as a driving force. This study applied similar approach as used by Narayan *et al.* (2010) based on daily data which was collected from 2000 to 2008. They jump to conclusion that first, a significant positive relation existed between gold and crude oil price during the entire study time. Secondly, a long term stable relation existed between both markets. Finally, the results specified that an increase in oil prices boost up the gold prices significantly.

Le and Chang (2011) studied the relationship between oil and gold prices by using cointegration approach, granger causality model and VAR method on monthly frequencies from the study period over 1986 to 2011. Their findings suggested that a long term pair wise relation existed among inflation, oil and gold during the study period. Further, the results of the study also confirmed that oil and gold assets are associated with a positive correlation through inflation. This means that a rise in oil prices would cause an increase in general price level which may increase gold demand and drives up its prices in the long run. Baffes (2007) analyzed a long data from 1960 to 2005, to study the movements in valuable metals including gold with oil prices. The study concluded that an increase in oil prices by one dollar would yield a rise in the price of gold by one dollar. This means that gold prices would strongly respond to changes in oil prices. On other hand, many authors also examined the volatility relation between gold and oil markets. Recently, Ewing and Malik (2013) used GARCH model to show volatility mechanism between oil and gold based on daily observations for study period from 1993 to 2010. The results indicated strong volatility dynamics between oil and gold markets.

2.4.2 Gold and Oil Price in Export Revenue Context

Secondly, gold and oil market are connected through export revenues. In literature, Melvin and Sultan (1990) documented the association between both markets during the study period from 1975 to 1988. The oil exporting economies invest in gold form their oil exports to oil importing countries and also maintain the status of gold as an asset by making a part of international reserve portfolios. Increase in oil prices may have implications in terms of higher gold prices and only proven, that gold accounts would be a part of the international assets portfolio if oil exporters purchase gold as a result of revenue collected from a sale of oil to other countries. As a result, rise in revenues would enhance the investment in gold market. Finally, increases in oil price originate the improvement in gold demand.

2.4.3 Gold and Oil Price in US dollar Context

Third, few studies also connect the gold price with US dollar because gold prices are determined in dollar in many countries of the world. However, US dollar and exchange rate also appear as important factors which explain the relationship between gold and oil market. Since 1975, gold and oil have been valued in United States dollar as OPEC formally sold oil commodity in US dollar. Koutsoyiannis

(1983) identified a negative association between the prices of gold and US dollar. Further, the results revealed that if gold and oil prices predicted by US dollar then US dollar considered a significant factor for liquidity. Kiohos and Sariannidis (2010) studied the determinants of gold prices, incorporated GJR-generalized autoregressive conditional heteroskedasticity approach on daily observations which was consisted of ten years data from 1999 to 2009. The findings suggested that crude oil and gold price maintained positive correlation but other variables such as United States dollar per yen exchange rate, stock market returns and Treasury bill suggested negative association with gold market.

Toraman, Basarir, and Bayramoglu (2011) studied factors which affect the gold price in United States. They incorporated the macroeconomic factors such as oil price, exchange rate, interest rate and US inflation during the time span from 1992 to 2010. The empirical findings recommended that gold price and US exchange rate maintained a negative relation. On the opposite side, oil and gold prices are associated with a positive correlation. Sindhu (2013) analyzed the impact of interest rate, repo rate, crude oil price and inflation on gold market in India by using five years data from 2006 to 2011. The findings indicated that gold and dollar dominated in US currency showed an inverse relation. While, positive association was found between oil and gold prices in Indian economy.

2.4.4 Gold and Oil Price in Interest Rate Context

Fourth, the relationship between oil and gold price has also been viewed through interest rate channel. In fact, values of commodities have been compared with low interest rate and fall in US dollar in many studies. Specifically, a limited literature is available to express the relationship between gold price and interest rate, but results of these studies also highlight the importance of interest rate which influences the gold prices. For example, Fortune (1988) explained that relation exists between nominal interest rate and gold prices. The results of study indicated that a rise in interest rate encourage the investors to sell a gold commodity and purchase those assets which provide higher rates of return. Further, an inverse relation between such variables also discourages the investors to reduce the gold investment which pushes down the gold prices in return. On the other hand, when the interest rate is low then people purchase commodities such as gold even bearing the storage cost of gold. However, when interest rates drop, people borrow money and spend more which drives-up oil demand and oil prices. Further, the empirical relation between commodity prices such as oil and gold, and interest rate provided mixed results. Gracia (2006) found a serial correlation between gold and interest rate in United States. In the study of Frankel and Rose (2010), the inverse relation could not be confirmed between real interest rate and oil price. Alquist, Kilian and Vigfusson (2013) found no relationship between real oil prices and real interest rate.

Contrary, Akram (2009) studied the relationship among prices of commodities, US dollar and interest rate for sample time from 1990 to 2007. This study applied VAR approach and found that when interest rate decreases, it leads to increase in commodities' prices. Finally, decline in the value of dollar also pushes up the commodities prices. Soytas *et al.* (2009) examined the short and long term relationship between commodities' prices and macroeconomic variables in Turkey during the five years from 2003 to 2007. They used variables such as bond rate, exchange rate, and Turkish Lira in relation to gold, silver and oil commodities. The study found an interesting result that oil prices would not be predicted through Turkish's interest rate in the long run because international markets have their own separate fundamentals for long time. Initially, a positive impact of oil prices has been noticed on gold prices. In the short run, interest rate would have positive impact on metals prices. Lee, Yang and Huang (2012) examined the movement of oil prices and returns in gold market using monthly observations from 1994 to 2011. The study found a nonlinear relation between oil price movement and gold market. Further, the result of study indicated a positive impact of oil prices on gold market. This means that oil price movements predict the gold returns. Baig *et al.* (2013) conducted a study in Pakistan and explored the relationship among stock market, gold and oil prices. This study applied monthly frequencies applied from 2000 to 2010 by incorporating the variance decomposition and cointegration approaches. The findings of study showed that gold and oil maintained a one to one relation.

The review of literature indicates that a few studies have documented the simple relationship among oil, gold assets and Pakistan Stock Exchange (KSE-100) in Pakistan. To the best of my knowledge, this study offers novelty to capture the diversification benefits of oil and gold assets, allocation of alternative assets in traditional portfolio of stocks and their hedging mechanism at industrial sector level by using multivariate GARCH models in Pakistan, which remain an unexplored area. During the adverse financial market situations, investors and portfolio managers require minimum risk or avoiding the bearish trends in stock market through hedging and portfolio diversification. By filling the above gap in literature, this study helps the investors and portfolio managers to choose defensive strategies such as hedge or purchase safe haven assets to complement the composition of portfolio of stocks. Furthermore, previous literature documented that volatilities of commodities explain stock prices and simultaneously oil and gold volatilities reflect negative impact on stock market (Lin *et al*., 2014; Sadorsky, 2014). This study offers another novelty to explore the presence of asymmetric volatility dynamics in oil, gold assets and stocks at sector level have also remained an unexplored area in Pakistan. The analysis of aggregate stock market index breakdown into sector level indices is important because it possibly counters the biases inherent in the use of aggregate equity index that may mask the sector specific characteristics (Arouri *et al.,* 2011). In addition, differences exist among sectors with respect to their structure, level of competition and role of oil as direct or indirect input/output in that particular sector (Xu, 2015). The previous literature also shows that some sectors of an economy may be severely affected by price volatility of oil because degree of response may vary across the sectors. Moreover, the novelty of applying the multivariate GARCH models on is based on well known fact that most of the studies use financial time series with features of volatility clustering, asymmetric effect and heavier tails. This makes the multivariate GARCH models a most feasible choice to apply on such series rather than applying the simple econometrics models such as co-integration test, vector error correction model. The study of these variables will enhance hedging benefits and diversification opportunities to investors for rebalancing their portfolio of stocks with dynamic correlation models over the time, especially in the context of Pakistani economy.

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CHAPTER 03

DATA AND METHODOLOGY

3.1 Data

The daily closing spot prices which consist of industrial sectors' stocks and alternative assets such as oil and gold, used for analysis which comprise of 3914 daily observations. This study covers the sample period from January 01, 2000 to December 31, 2014. The data for analysis starts from year 2000 because of rising trend of financial activities in commodity market after technology stock market crash. In addition, the wealthy individual investors and institutional investors have started to hedge their equity positions by investing in commodity market in year 2000. Further, recent studies (Erb & Harvey, 2006) concluded an inverse relation among equities and commodities. As a result of these studies, the investment of dollar thirteen billion has made by investors in 2003 which further increased more than two hundred dollar billion in 2008 (Tang & Xiong, 2012). Furthermore, the selected time duration particularly covers the Global Financial Crisis 2007-2009 to verify that this crisis has disrupted or strengthened positive or negative correlation among alternative assets and industrial sector indices. Having less global connectivity of Pakistan's economy with the world, the impact of Global Financial Crisis 2007-2009 is not strongly transmitted to stock market in Pakistan (Draz, 2011). If this is so, this study utilizes the full sample period data because the breakdown of full sample period into sub-sample such as pre-crisis, crisis and post crisis is not appropriate for analysis purpose. For industry level data, Pakistan Stock Exchange (PSX) is classified into ten different economic industrial sectors namely; Basic Material, Consumer Services, Consumer Goods, Financials, Health Care, Industrials, Oil and Gas, Telecommunication, Technology and Utilities sectors. These industries are classified according to Industry

Classification Benchmark (ICB) developed by FTSE and Dow Jones in 2005. The Technology sector is an unexplored industrial sector at the time of writing this thesis because of unavailability of data on DataStream. To represent the commodities, the oil and gold assets are used for analysis because oil and gold are most tradable commodities in the world[4]. The West Texas Intermediate (WTI) is used as a reference for crude oil prices (dollar per barrel), served as a benchmark for oil market and commodity portfolio diversification. For gold bullions, Chicago Mercantile Exchange (CME) continuous futures served for gold prices expressed in US dollar per Troy ounce. Whereas, the prices of industrial sector indices are measured by multiplying the each day index price with particular dollar rate (USD / Pak Rupee) for every day. The data for industrial sector indices, crude oil and gold prices are extracted from DataStream Thomson Router.

3.2 Empirical Methodology

Modeling volatility and correlation of asset or investment's return is the central issue for any financial activities. The volatility of returns is the main technique to estimate the investment risk and correlation helps interpreting the association among assets in portfolio or available in market. It is well known that volatility of assets move over time and high volatility triggers high volatility and vice versa. Further, a large change in asset returns is followed by other large change. This phenomenon is known as financial time series volatility clustering. Owing to this fact, Engle (1982) proposed volatility model namely ARCH model which widely use to describe and forecast time-varying variances.

[4] According to the CME Group Leading Products Resource, oil and gold are most traded commodities in the world wide (http://www.cmegroup.com/education/featured-reports/cme-group-leading-products.html)

3.2.1 Univariate Models

3.2.1.1 Univariate Autoregressive Conditional Heteroskedasticity (Univariate ARCH) Model

Mostly, financial time series observe unequal jumps with high volatility and then back to normal condition. The existence of sudden jump shows that a constant variance assumption does not hold most of the cases. Accordingly, unstable variances or volatility in financial time series is not directly observable, a need of a good model is necessary to predict the future volatilities. Considering this fact, Engle (1982) presented ARCH model based on assumption that variance of residuals in time series are not constant or are heteroskedastic over time. The ARCH model suggest that today's variance of residuals depends on squared error term of past periods or heteroskedasticity because variance will change over time. However, The ARCH (q) model is presented as follows:

$$\mathrm{r_t} = \mathrm{u_t} + \varepsilon_{\mathrm{t}} \tag{3.1}$$

Where

$$\varepsilon_{\mathrm{t}} = \sqrt{\mathrm{h_t}}\, Z_t \qquad Z_t \sim iid\ N\ (0,1)$$

ε_{t} is mean zero innovation with a normal stochastic course, assumed to be:

$$h_t = \omega + \sum_{j=1}^{q} \alpha_j\, \varepsilon_{t-j}^2 \tag{3.2}$$

In equation (1), $\mathrm{r_t}$ is return of asset at time t, $\mathrm{u_t}$ is the mean of asset and ε_{t} represents the error term of return at time t. For equation (2) h_t is conditional variance which is calculated by weighted average of past error terms, the estimated coefficient of ω and α are assumed to positive for non-negative variances. ε_{t-j}^2 is the squared error term for time t.

3.2.1.2 Univariate Generalized Autoregressive Conditional Heteroskedasticity (Univariate-GARCH) Model

One drawback of the ARCH model is that it looks more like a moving average specification than an autoregressive. For this purpose, a new idea was presented which include the lagged conditional variance terms as autoregressive terms. The GARCH (Generalized Autoregressive Conditional Heteroskedasticity) specification is the extension of ARCH model which is proposed by Bollerslev (1986), starting a new family of GARCH models.

GARCH (p, q) model can be written as:

$$h_t = \omega + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{3.3}$$

Where, h_t depends on past value of the shocks and on past values of itself which is captured by lagged squared error terms (ε_{t-j}^2) and lagged conditional variance (h_{t-j}), respectively.

3.2.2 Multivariate GARCH Models

Volatilities of financial time series move independently but the patterns shows that volatilities move together eventually in financial market. It is also widely accepted that volatility of asset's returns, covariance and correlations are not constant over time. Further, pricing of assets in a portfolio depends on covariance of assets, risk management and allocation of asset related to find and update the optimal hedging ratios (Bollerslev, Engle, & Wooldridge, 1988). Owing to these features, a single univariate GARCH model cannot capture given characteristics. The multivariate GARCH models are more relevant than working with univariate GARCH specifications (Bauwens, Laurent, & Rombouts, 2006). However, the modeling of multivariate time series has two directions, which is as follows:

1. Modeling conditional variance-covariance matrix directly.
2. Modeling the correlation between time series indirectly.

3.2.2.1 Models for Conditional Variance-Covariance Matrix

3.2.2.1.1 VEC-GARCH Model

The VEC-GARCH is the first multivariate GARCH model proposed by Bollerslev *et al.* (1988) which is pure general representation of univariate GARCH model. The VEC multivariate model writes the co-variance matrix as vectors. The model suggests that every conditional variance and covariance is the function of all lagged conditional variances and covariances, as well as lagged squared errors and cross-product of errors. The specification of the model is expressed as:

$$vech(H_t) = C + \sum_{j=1}^{q} A_j \, vech\left(\varepsilon_{t-j}\acute{\varepsilon}_{t-j}\right) + \sum_{i=1}^{p} B_i \; vech\,(H_{t-i}) \tag{3.4}$$

In equation (4), $vech$ is the operation that stacks the lower diagonal values of a matrix into a column vector. C is the parameter vector of constant term with order of N (N+1) / 2 × 1 vector. H_t is the covariance matrix of error terms. $\varepsilon_{t-j}\,\acute{\varepsilon}_{t-j}$ represents the cross product of error terms and the lagged elements of H_{t-j} .A_j and B_i are the parameter matrices with the order of $\frac{1}{2}\,N(N+1) \times \frac{1}{2}\,N(N+1)$.

3.2.2.1.2 Diagonal VEC-GARCH Model

One of the main problems of VEC model is the curse of dimensionality. The number of parameters are 21 when $N = 2$, If N equals to 3 then there is a need to estimate the variance by using 78 parameters which shows a large number of parameters to be estimated. Further, this model cannot ensure the positive definiteness of the variance-covariance matrix (H_t) which is assumed to be positive semi-definite (Brooke, 2008). However, to counter the problem of large number of parameters, Bollerslev *et al.* (1988) proposed a DVEC-GARCH model with diagonal element of parametric matrices A_j and B_j.

3.2.2.1.3 BEKK-GARCH Model

The drawback of VEC-GARCH model is that it is hard to guarantee the positive definiteness of the variance-covariance matrix (H_t). To circumvent the said problem, the BEKK Model proposed by Engle and Kroner (1995), written as follows:

$$H_t = CC' + \sum_{j=1}^{q} A_j \left(\varepsilon_{t-j}\acute{\varepsilon}_{t-j}\right) A'_j + \sum_{i=1}^{p} B_i \ (H_{t-i})\, B'_i \tag{3.5}$$

A_j , B_i and C are $N \times N$ parameter matrices in equation (5). C is the lower triangular matrix. Further, the decomposition of constant term into a product of two triangular matrices (CC') ensures H_t is guaranteed to be non-negative.

3.2.2.2 Models for Conditional Variance and Correlations

Another way for Multivariate GARCH model is to estimate the correlation indirectly between the financial time series as an alternative of modeling the conditional variance covariance matrix directly. The correlations for time series are estimated through decomposition of the conditional variance-covariance matrix into conditional variance and correlations.

3.2.2.2.1 Constant Conditional Correlation GARCH (CCC-GARCH) Model

The constant conditional correlation-GARCH model is developed by Bollerslev (1990) based on assumption that the correlations among assets or series must be constant over time. This model is a useful attempt to investigate the multivariate GARCH model indirectly in the correlation direction instead of exploring the variance covariance matrix directly. However, the CCC-GARCH model assumes that conditional correlation matrix is constant and conditional variance matrix is varying with the passage of time. Hence, the structure of conditional covariance matrix (H_t) is defined as:

$$H_t = D_t \; P_t \;\; D_t \tag{3.6}$$

In equation (6), $D_t = diag\ (h_{1t}^{\frac{1}{2}} \ldots\ldots h_{Nt}^{\frac{1}{2}})$, D_t represents a diagonal matrix of time-varying conditional variance from univariate GARCH process. P denotes (NXN) constant conditional correlations matrix. The positive definiteness of the variance covariance matrix is controlled by correlation matrix. So, the positive definiteness of H_t is satisfies if the h_t is properly specified and conditional correlation matrix (P_t) is positive for all t.

3.2.2.2.2 Dynamic Conditional Correlation GARCH (DCC-GARCH) Model

The assumption of constant correlation across different assets and markets may seem unrealistic and empirical analysis rejects this assumption. For instance, Tsui and Yu (1999) tested the validity of constant conditional assumption by using Chinese stock market data. They concluded that the null hypothesis, constant conditional correlation, cannot be supported in stock returns. Regarding this fact, Engle (2002) proposed a model called DCC-GARCH model, with time-varying structure of conditional correlations.

The DCC model presented by Engle (2002) is estimated in two steps: In the first step, the GARCH parameters are estimated and in the subsequent step, correlations are estimated. The DCC model allows the correlation matrix to be time-varying with motion dynamics, such that

$$H_t = D_t P_t D_t$$

Where, D_t is $(N \text{ x } N)$ diagonal matrix of dynamic conditional variance on diagonal, estimated from univariate GARCH models and H_t is conditional covariance matrix. P_t is possible dynamic correlation matrix.

$$D_t = \text{diagonal } (h_{1,t}^{1/2} ,\ldots\ldots h_{n,t}^{1/2}) \tag{3.7}$$

P_t = diagonal ($q_{1,t}^{-1/2}$,…..$q_{n,t}^{-1/2}$) (3.8)

In equation (7) h notation indicates the time varying covariance matrix estimated through univariate GARCH models and the elements of H_t (conditional covariance matrix) for GARCH (1, 1) model can be written as:

$h_{i,t} = \omega_i + \alpha_i\ \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}$ (3.9)

The evaluation of time-varying conditional correlations in DCC-GARCH model is decomposed in the following:

$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1\ z_{t-1}\ z_{t-1}^{'} + \theta_2 Q_{t-1}$ (3.10)

In equation (10) Q_t is $(N \text{ x } N)$ diagonal conditional correlation matrix of residuals ($z_{i,}$) at time t. The dynamic conditional correlations are extracted through parameters θ_1 and θ_2. The summation of these parameters is less than 1 which shows a mean reverting behavior of correlations over time.

In DCC-GARCH model, the conditional cross correlation among residuals of the series is estimated as follows:

$\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,i,t} q_{j,j,t}}}$ (3.11)

Where, $\rho_{i,j,t}$ provides the conditional cross correlation between residuals of the series, $q_{i,j,t}$ is the cross covariance estimator and $q_{i,i,t} q_{j,j,t}$ are the variances of the residuals.

3.2.2.2.3 Asymmetric Dynamic Conditional Correlation GARCH Model

According to Cappiello *et al.* (2006), the DCC-GARCH approach does not account the important feature of financial time series, called asymmetric effect. The asymmetric effect indicates that negative innovation in returns increases the future volatility as compared to positive innovations of the equal size. Cappiello *et al.* (2006) found the evidence for presence of asymmetric volatility in stock returns and bond returns. Finally, stock returns showed a strong response towards bad news comparing with bond returns.

Recently, it is observed that there is presence of asymmetric effect in conditional correlations. The main effect of ignorance of asymmetric creates mispricing of assets, poor forecasting, which are the key factors for asset allocation and risk management. In general, negative news increases the variance of two assets return indicating investors to expect more returns from investment in risky assets (Cappiello *et al.*, 2006). As a result, the price of stock and bond decreases and correlation increases, particularly during financial market crisis. Hence, DCC-GARCH model does not accommodate the asymmetric effect in correlations across different assets. To capture this, Cappiello *et al.* (2006) provided the multivariate asymmetric DCC-GARCH (ADCC-GARCH) model. We simply extend the equation (9) with the asymmetric function, as given below:

$$h_{i,t} = \omega_i + \alpha_i\, \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + d_i\, \varepsilon_{i,t-1}^2 I(\varepsilon_{i,t-1}) \qquad (3.12)$$

The asymmetric GARCH (1, 1) in equation (12), present the indicator function $I(\varepsilon)$ for $\varepsilon > 0$. In asymmetric dynamic conditional correlation GARCH model, the positive value of d indicates that negative conditional residuals tend to increase the volatility in future more than positive shocks of the same magnitude. Further, notations such as α and β are for short term persistence (ARCH) and short term persistence (GARCH), respectively. The symmetric positive definite matrix (Q_t) is mathematically expressed as:

$$Q_t = (\bar{Q} - A'\bar{Q}A - B'\bar{Q}B - G'\overline{Q^-}G) + A'z_{t-1}z_{t-1}'A + B'Q_{t-1}B + G'z_t^- z_t^{'-} G \qquad (3.13)$$

Where A, B and G are n x n parameter matrices, standardize residuals (z_t^-) = z_t and $z_t < 1$ and 0 otherwise. The unconditional matrixes are $\bar{Q}$ and $\overline{Q^-}$ represents the z_t and z_t^-, respectively.

3.2.2.3 Factors Model

Originally, the factor ARCH model is developed by Engle, Ng, and Rothschild (1990) with the foundation of Ross (1976) arbitrage pricing theory. Factor ARCH model assumed that returns are generated by a set of unobserved underlying factors that are conditionally heteroskedastic and possess a GARCH-type structure.

3.2.2.3.1 Generalized Orthogonal-GARCH (GO-GARCH Model)

The dependence framework is non-dynamics as a consequence of large estimation in multivariate setting. The dependence structure of the unobserved factors then determines the type of factor model it belongs to and; correlated factors making up the F-ARCH type models. By contrast, uncorrelated and independent factors comprise an orthogonal and generalized orthogonal model, respectively.

However, consider a set of N assets and assets returns (r) are observed at time t as a function of mean (m) at time t, error term (ε) at time t with autoregressive term AR (1) than:

$$\mathrm{r_t} = \mathrm{m_t} + \varepsilon_\mathrm{t} \qquad \mathrm{t} = 1, \dots, \mathrm{T} \tag{3.14}$$

The GO-GARCH model (Van der Weide, 2002) maps $\mathrm{r_t} - \mathrm{m_t}$ a set of unobserved underlying independent factors (f) at time t. Hence,

$$\varepsilon_t = A f_t \tag{3.15}$$

A is a mixing matrix which is decomposed in to square root of the unconditional covariance $(\Sigma^{1/2})$ and an orthogonal matrix, U, so that: $A = \Sigma^{1/2} U$. In mixing matrix rows indicate the assets and columns indicate the factors. The factors in matrix shown as:

$$f_t = H_t^{1/2} z_t \tag{3.16}$$

In equation (16), random variable (z_t) having zero mean and variance one.

Further, $h_{i,t}$ is conditional variance of factor which modelled as a GARCH type process. The unconditional distribution of the factors (f), satisfy:

$E = (f_t) = 0, E = (f_t, f_t^{'}) = 1$

By combining the three equations (14), (15) and (16), returns can be represented as:

$$\mathrm{r_t} = \mathrm{m_t} + H_t^{1/2} z_t \tag{3.17}$$

The $(r_t - m_t)$ is conditional covariance matrix of the returns is expressed as:

$\Sigma_t = AH_t A'$

3.2.3 Multivariate GARCH Models Selection

On large data set, the estimation of multivariate GARCH creates challenges. These models do have some limitations in which three variables are modeled jointly in a multivariate GARCH structure. The VECH model has a large number of free parameters which make it impractical while using more than two variables. The diagonal VECH (D-VECH) model lacks correlation among the error terms. BEKK model is hard to estimate for more than two variables because of poorly behaved likelihood function. To address these problems, restricted correlations models such as CCC-GARCH, DCC-GARCH and ADCC-GARCH models are designed. Among restricted correlations models, this study applies baseline M-GARCH specifications (DCC-GARCH, ADCC-GARCH and one factor model namely GO-GARCH) for comparison purpose because comparing results from different M-GARCH models is helpful in understanding how hedge ratios vary with the selected estimation technique (Basher & Sadorsky, 2016).

This study adopts relevant multivariate models to scrutinize the first three objective of the study. Moreover, these selected models account the important features of time series data. **1).** The DCC-GARCH approach of Engle (2002) is appropriate to examine the symmetry in time series (Arouri *et al.*, 2011; Lin *et al.*, 2014), time-varying correlations between financial variables and commodities (Ciner *et al.*, 2013). Many previous authors (Hammoudeh *et al.*, 2010; Chang *et al.*, 2013) also applied the DCC-GARCH model to study the time-varying correlations and hedging strategies among financial assets. The dynamic conditional correlation model measures the persistence in both conditional correlation and volatility. **2).** The ADCC model of Cappiello *et al*. (2006) which is extended form of the DCC, allows to take into account the important feature of financial time series 'asymmetry' (Chkili, 2016). **3).** The GO-GARCH model (Van der Weide, 2002) captures the effects of volatility spillover under linear transformation, time-varying correlations and volatilities, and asymmetric volatility spillover. The GO-GARCH model is less use in practice but tricky to estimate (Basher & Sadorsky, 2016). Finally, these models shed light on portfolio diversification, optimal weights and hedge ratios for oil/gold-stock portfolio holding at sector level in Pakistan.

3.2.4 Multivariate GARCH Model Estimation

For model estimation, first, this thesis estimates the several versions of DCC model which consist of GARCH (1, 1) mean equation and variance equation for all industries, shown in Appendix B. The adjustments are made with respect to choice of distribution and including the autoregressive (1) term in GARCH mean equation which is constant. All models selection criterion including; AIC, BIC and HQ indicate that DCC with MVT distribution is best fitted model with an AR (1) term in GARCH (1, 1) mean equation. Accordingly, AR (1) term in mean equation is also used for all multivariate models such as DCC-GARCH, ADCC-GARCH and GO-GARCH for estimation. Further, DCC and ADCC models are estimated with MVT distribution for non-normality in returns distribution and GO-GARCH model is estimated with other distribution namely multivariate affine negative inverse Gaussian because multivariate t-distribution is not applied for GO-GARCH model.

3.3 Time-varying Hedge Ratios

The purpose of the study is to investigate the hedging dynamics of alternative assets for stocks portfolio at industrials sector level and to examine hedge properties of alternative assets depend on the business nature of a particular sector in Pakistan. In this context, the hedge ratio (HR) is widely used strategy based on the available information at time t (for example, Chkili, 2016; Wang and Wu, 2012; Hammoudeh, Yuan & McAleer, 2009; Kroner & Sultan, 1993). So, returns of the portfolio of stocks at sector level and oil/gold pairs written as:

$$R_{H,t} = R_{Stock,time} - \gamma_t R_{oil/gold,time} \tag{3.18}$$

Where, $R_{H,t}$, $R_{Stock,time}$ and $R_{oil/gold,time}$ represent the return of hedged portfolio, return of stock and returns of oil/gold at time t , respectively. The γ_t represents the hedge ratio (HR), which indicates that, the hedger can take the long position (selling position) in dollar in stock by short position (buying position) in dollar in commodity market. Further, the variance of the hedged portfolio conditional on the information set at time $(t-1)$, writtern as:

$$Var\ (R_{h,t}\, I_{t-1}) = Var\ (R_{s,t}\, I_{t-1}) - 2\gamma_t Cov\ (R_{oil/gold,t}\, , R_{s,t}\, I_{t-1})$$

$$+\gamma_t^2 Var(R_{oil/gold,t}\, I_{t-1}) \tag{3.19}$$

Here, γ_t indicates the optimal hedge ratios, used to minimize the variance of the hedged portfolio. This term is equivalent to zero (Baillie & Myers, 1991) and by taking partial derivative of variance on information set I_{t-1} the hedge ratio can be calculated as:

$$\gamma_t^* I_{t-1} = \frac{Cov\left(R_{s,t} R_{oil/gold,t} \middle| I_{t-1}\right)}{Var\ (R_{oil/gold,t}\ | I_{t-1})} \tag{3.20}$$

The conditional volatility parameters obtained from DCC, ADCC and GO-GARCH models, applied to extract the optimal hedge ratio (Kroner & Sultan, 1993). As a result, the subsequent method is used to estimate the hedge ratio between spot price and future price.

$$\gamma_t^* I_{t-1} = h_{s,o/g,t}\ /\ h_{o/g,t} \tag{3.21}$$

In equation (21), $h_{s,o/g,t}$ is denoted for the conditional covariance of returns between stock and oil/gold price at time t. The $h_{f,t}$ notation represents the conditional variance of oil/gold returns at time t.

3.4 Optimal Portfolio Weights

This study also aims to scrutinize the optimal portfolio choices for investors at sector level stocks. Furthermore, the objective of investors is to minimize the risk of oil-stock portfolio and gold-stock portfolio without lowering the expected returns. For this, the optimal portfolio weights are constructed assuming that expected returns of all assets are. Further, the conditional volatilities obtained from DCC, ADCC and GO-GARCH models; are used to construct the optimal portfolio weights. According to Kroner & Ng (1998), the portfolio weights can be calculated as:

$$w_t^{s,o/g} = \frac{h_t^s - h_t^{so/g}}{\mathrm{h}_t^{\mathrm{o,g}} - 2h_t^{so/g} + h_t^s} \qquad \text{with} \quad w_t^{s,o/g} = \begin{cases} 0, if\ w_t^{s,o/g} < 0 \\ w_t^{s,o/g}, if\ 0 \leq w_t^{s,o/g} \leq 1 \\ 1, if\ w_t^{s,o/g} > 0 \end{cases} \tag{3.22}$$

Where h_t^s is volatility of stock (sectoral stocks), $h_t^{o,g}$ represents the volatility in oil and gold market, $h_t^{so/g}$ represents the conditional covariance between oil-stock and gold-stock, respectively, at time t. $w_t^{s,o/g}$ indicates the weight of oil in one dollar portfolio of the two assets (oil and stock sector index), weight of gold in one dollar portfolio of the two assets (gold and stock sector index). The weight of each sector index in portfolio oil/ gold-stock will be obtained by finding the $(1 - w^{s,o})$ and $(1 - w^{s,g})$, respectively. Similarly, this method is used by Chkili, 2016; Wang and Wu, 2012; Hammoudeh *et al.*, 2010) to construct the optimal portfolio holding two assets.

CHAPTER 04

RESULTS AND DISCUSSION

4.1 Preliminary Findings and Descriptive Results

The daily returns of all industrial sector indices and commodities i at time t continuously compounded calculated:

$$Daily\ Return\ (i,t) = Log(\frac{Price_{i,t}}{Price_{i,t-1}}) \tag{4.1}$$

Where, $Price\ i,t$ and $Price\ i,t-1$ are daily closing price or settlement prices i for time t and $t-1$, respectively. The daily time series data of industrial sector stock indices and commodities are shown in Appendix-A, covering the sample time period 2000 to 2014 for the total 3913 observations. The highest value (i.e. 9.2044) is observed on March 14, 2008 and the lowest value on December 30, 2008 which shows a big impact on basic material sector at the time turbulence time 2007-2009. The consumer services sector demonstrates a lowest value on July 30, 2001 for pre-global crisis period 2007-2009. However, a maximum value (i.e. 14.7398) is observed on October 22, 2007 during crisis time which drops at lowest on March 02, 2009. The consumer goods sector's prices exhibit a large spike around the financial crisis 2007-2009 and drop down to 2.5017 on February 23, 2009 but a rarely stable trend is found in prices during the whole study period. For financial sector, raw data displays a strong an upward trend before global recession 2007-2009. The recession time exerts a big impact on financial sector companies as the finacial sector index drops to lowest value 11.01on January 19, 2009. A plot of raw data for health care sector shows an upward trend upto first half of financial crisis 2007-2009, but health care sector's index drops in next period upto last quarter in 2010 with the value 2.9811. The behavior of industrial sector's prices clearly shows three main trends: an upward trend from 2000 to the start of 2008, downward trend from start of second quarter 2008 to first month of 2009, with price rising progressively to peak point in December 2014, which indicates an unstable trend around the average values. However, a constant an upward trend is severely reversed within a short period of time form April 2008 to January 2009. The time series plots for oil and gas sector index shows instability in prices during the whole study period. A large drop in index value is found during the bad time in financial market. An upward movement in values is noticed for a short time. The telecommunication sector displays a large spike in 2005 and a downward trend is found during the global recession, but values move slightly till the end of 2014. The prices of utilities sector index demonstrate an irregular pattern during the whole study period. The prices of crude oil show a continuous upward trend from year 2000 and recorded 145.28 dollar per barrel in July 2008, while, oil prices decreased for a short time in second half of 2008. Finally, an upward trend in crude oil prices is restored in 2009. The gold prices provide a strong an upward trend during the Global Financial crisis 2007-2009, but a downward trend in gold prices is also viewed at the start of third quarter till the end of 2014. The common opinion of economic specialists is that gold act as safe haven assets in equity markets during the economic stress.

Further, the behavior of squared daily returns over time for all time series are shown in Appendix-B, which indicates how volatility has changed over the study period. Each series shows a several periods of volatility clustering throughout the study period. Particularly, each series shows volatility clustering around Global Financial Crisis 2007-2009 but this effect is prominent for basic material, health care, industrial, oil and gas, telecommunication and utilities sectors. Oil asset displays a big spike as compared to gold asset during the economic turbulence.

The descriptive statistics summary for the daily returns of industrial sector stock indices, oil and gold assets are reported in Table 4.1, which indicates that daily average returns are positive for all industrial sectors and commodities except telecommunication sector. The basic materials sector index observed daily average return of 4.0 %. While, mean return of consumer services sector index is 4.3%. The utilities sector index shows a lowest average return i.e. 1.8 % as compared to other sectors. Whereas, health care sector realizes a relatively similar return i.e. 3.8% as the industrial sector return. Furthermore, consumer goods sector provides daily average returns 2.8%. The financial sector specifies a best performing sector in Pakistan with highest average return (6.6 %). The oil and gas sector has 4.6 % average return on daily basis. The telecommunication sector posts a negative average return (-1.6%) which shows worse performance. In case of commodities (Panel-B), gold has outperformed with an average return 3.6 % than oil during the period under consideration. Daskalaki and Skiadopoulos (2011) and Jensen, Johnson and Mercer (2000) also indicate that gold offers highest returns when compared with other commodities. The standard deviation of basic material sector and consumer services sector are similar (1.6). The health care sector index and financial sector index also indicates similar results for standard deviation (1.7). While, the standard deviation for consumer goods sector is 1.9 and, oil & gas sector provide an average value that is 1.8 Furthermore, utilities sector show highest standard deviation i.e. 2.1, among all sectors and Industrial sector has lowest value i.e., 1.5. In case of commodities, gold provides the lowest standard deviation value and oil presents highest standard deviation value. The Coefficient of variation indicates that utilities sector by large amount has the amount of variability while, as compared to other sectors, a financial sector shows a least amount of variability. Approximately, basic materials sector, consumer services sector, industrial sector and, oil & gas have shown similar variability. Consumer goods sector experienced amount of variability i.e. 69%. For commodities, highest value of coefficient of variation observed for oil by comparing with gold commodity. Jarque Bera test rejects the null hypothesis (that series are normally distributed) and states that returns of all series are not normally distributed. ARCH (12) Lagrange multiplier (LM) statistics for serially correlated squared returns in all series up to lag 12, which reject the null hypothesis (that no ARCH effect exist) and indicates the strong proof of ARCH effects likely to be found in the all return series. Thus, the selection of GARCH models such as DCC-GARCH, ADCC-GARCH and GO-GARCH specifications are appropriate in order to investigate the volatility dynamics among stock market and alternative assets i.e. oil and gold.

Table 4.1 Descriptive Statistics Summary for daily returns

	Mean	**Var**	**S.D**	**Coef. Var**	**J.B**	**ARCH (12)**
Basic Materials	0.0397	2.489	1.5777	39.6978	2946***	450***
Consumer Services	0.0427	2.5956	1.6111	37.7673	3361***	425***
Consumer Goods	0.0277	3.6032	1.8982	68.4660	1635***	345***
Financials	0.0658	3.0501	1.7465	26.5252	7642***	226***
Health Care	0.0379	2.7558	1.6600	43.6960	813***	489***
Industrials	0.0384	2.2191	1.4897	38.7641	2244***	619***
Oil & Gas	0.0457	3.1562	1.7766	38.8601	1504***	696***
Telecommunication	-0.0155	5.1557	2.2706	-146.412	2167***	331***
Utilities	0.0109	4.492	2.119	195.200	7687***	390***
Oil	0.0187	5.5807	2.3623	126.1473	5382***	498***
Gold	0.0359	1.3092	1.1442	31.8601	5688***	224***

Notes: This table shows descriptive statistics for daily return series for all sectoral stock indices, oil and gold commodities. Variance is denoted by Var, Standard deviation shown by S.D, Coef. Coefficient of variation is represented by Coef.Var. Jarque- Bera test statistics shown as J-B. The Lag range multiplier test for autoregressive conditional heteroskedasticity of order 12 is shown as ARCH (12). The significance level at 1% is shown by an asterisk (***).

4.2 Unconditional Pair-wise Pearson’s Correlation

Table 4.2 depicts the unconditional Pearson’s correlation among pair of returns for sectoral stock indices; oil and gold assets. It can be seen that correlations vary across all pair of returns. As expected, the correlation between basic materials sector index and oil pair is 0.0059 which indicates an insignificant relation. The basic materials sector index and gold pair provides a week positive correlation i.e. 0.0032 which states that no significant relation exists between the two assets’ returns. Whereas, a negative an insignificant correlation (-0.0099) exists between consumer services and oil returns but a positive correlation (0.0060) arises with gold returns which is an insignificant. For consumer goods sector, a negative insignificant correlation exists with oil and gold returns a desirable for risk management point of view. Moreover, an insignificant week positive correlation value is observed between financial sector index returns, oil and gold returns. The health care sector has very weak positive relation with oil and negatively an insignificant correlation with gold returns. The industrials sector indicates a positive correlation i.e. 0.0063 and 0.0074, respectively which states no significant relation exists among these assets’ returns. The oil and gas sector exhibits statistically an insignificant positive relation with oil and a negatively correlate with gold returns. The telecommunication sector returns negatively correlate with oil and gold market returns. While, an insignificant positive relation exists among utilities sector returns, oil and gold returns. Overall, the unconditional correlations’ values between all pairs are statistically insignificant. The possible reason may be that the operational requirements of all industrial sectors in Pakistan are not strongly integrated to worldwide macroeconomics factors. Due to weak connectivity of Pakistani stock market with the world economy, the factors affecting international stocks markets may transmit a comparatively weaker impact on stock market in Pakistan. However, it is worth noting that an inference based on a simple linear correlation measure, without accommodating the serial correlation and conditional heteroskedasticity, can be misleading. Hence, a thorough examination of the co-movement of returns and volatility structure between the assets returns is necessary.

Table 4.2 Unconditional Pearson's correlation results between daily returns

Industrial Sector	Oil Returns	P-Values	Gold Returns	P-Values
Basic Material	0.0059	[0.7142]	0.0032	[0.8407]
Consumer Services	-0.0099	[0.5340]	0.0060	[0.7055]
Consumer Goods	-0.0013	[0.9338]	-0.0073	[0.6475]
Financials	0.0106	[0.0840]	0.0150	[0.3471]
Health Care	0.0009	[0.9548]	-0.0106	[0.5093]
Industrials	0.0063	[0.6938]	0.0074	[0.6413]
Oil & Gas	0.0084	[0.5973]	-0.0004	[0.9789]
Telecommunication	-0.0077	[0.6308]	-0.0178	[0.2656]
Utilities	0.0220	[0.1682]	0.0122	[0.4470]

Notes: Values in [ ] indicates p- values.

4.3 Results for Multivariate-GARCH Models' Parameters

4.3.1 Basic Materials Sector, Oil and Gold Assets

The estimation results for all models are provided in Table 4.3 for basic materials sector index, oil and gold). In mean equation, the estimated coefficients which measured through DCC and ADCC models for conditional mean (μ) are positive and statistically significant for basic materials sector index, oil and gold assets. The conditional mean values are highest as detected for basic materials sector index. The estimated coefficients of an autoregressive term (a) are positive and statistically significant for basic materials sector index and negatively significant in the case of oil and gold assets. In variance equation, the estimated coefficient of α term is statistically significant which describes the evidence of short-term persistence of volatility. While, the estimated coefficient of β is statistically significant which provide the evidence of long term persistence of volatility and greater than short-term persistence (α). The statistical significance of α and β indicates the evidence of volatility clustering in all these markets. Moreover, the sum value of α and β is also less than unit illustrating that shocks to volatility are dissimilar across markets. These results re-confirm that investors and portfolio managers will earn the high returns on investment for short time; constant with the findings of Rahim & Mashi (2016).

The estimated coefficients of θ_1 and θ_2 are positive but only θ_2 is statistically significant at 1% level, indicating that the assumption of constant conditional correlation is not supported empirically for basic materials sector index, oil and gold pairs. This means that dynamic conditional correlations are mean reverting among all pairs. The coefficients of shape parameter (λ) are over 4 and 6 for basic materials sector index and oil, respectively. While, a lowest estimated coefficients values (i.e., 4) of shape parameter are observed for gold asset, which indicate that gold has heavier tail distributions then the distributions of oil. The assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by abnormal returns originate from assets returns with heavy-tail distribution (Mainik *et al.*, 2015). It means that gold with heavier tails provide better diversification benefits in mixed assets portfolio comparing with oil asset.

The estimated coefficient for the asymmetric effects (γ) estimated through ADCC model is positive providing the evidence that negative residuals tend to increase the conditional volatility (variance) more than the positive shocks of the same magnitude in basic materials sector index and oil equations. Whereas, the estimated coefficient for the leverage effects is negative for gold which indicates that negative residuals tend to decrease the variances more than positive shocks. These results confirm the findings of Basher & Sadorsky (2016). In case of GO-GARCH specification, a long-term persistence (GARCH effect) is greater than short-term persistence (ARCH effect) for each factor of basic materials sector index, oil and gold assets. These results are similar with the findings of DCC and ADCC models. The model selection criterion measures the relative goodness of fit of the estimated models which indicates that DCC-GARCH is fitted model.

Table 4. 3 DCC, ADCC and GO-GARCH Parameters Estimates for Basic Materials Sector Index, Oil and Gold

	DCC			**ADCC**		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
$\mu_{\text{BM Index}}$	0.1219***	0.0183	6.6471	0.1069***	0.0189	5.6699
$a_{\text{BM Index}}$	0.0596***	0.0168	3.5420	0.0670***	0.0172	3.8995
$\omega_{\text{BM Index}}$	0.0798***	0.0192	4.1589	0.0934***	0.0206	4.5254
$\alpha_{\text{BM Index}}$	0.1678***	0.0198	8.4934	0.1044***	0.0185	5.6394
$\beta_{\text{BM Index}}$	0.8196***	0.0196	41.8827	0.8146***	0.0202	40.3354
$\lambda_{\text{BM Index}}$	4.6828***	0.3380	13.8537	4.7740***	0.3486	13.6968
$\gamma_{\text{BM Index}}$				0.1136***	0.0273	4.1641
μ_{Oil}	0.0567**	0.0275	2.0641	0.0494*	0.0275	1.7953
a_{Oil}	-0.0331**	0.016	-2.0686	-0.0332**	0.016	-2.0713
ω_{Oil}	0.0187***	0.0065	2.8955	0.0177***	0.0064	2.7668
α_{Oil}	0.0395***	0.0024	16.2455	0.0246***	0.005	4.9496

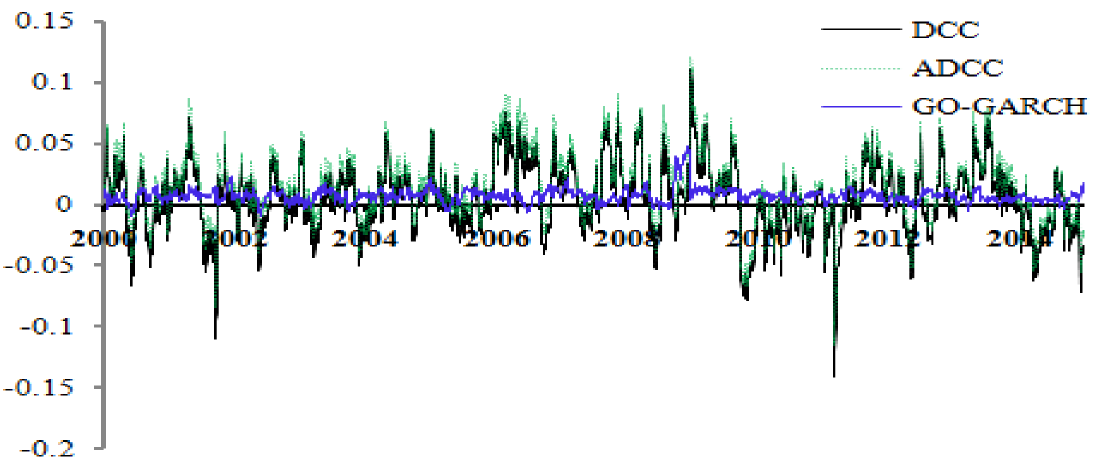
β_{Oil}	0.9578***	0.0006	1518.6615	0.9597***	0.0005	1855.9073
λ_{Oil}	6.3873***	0.628	10.1704	6.4562***	0.6402	10.0845
γ_{Oil}				0.0253***	0.009	2.8051
μ_{Gold}	0.0479***	0.0127	3.7866	0.0522***	0.0126	4.141
a_{Gold}	-0.0325***	0.0143	-2.2736	-0.0344***	0.0144	-2.3818
ω_{Gold}	0.0084***	0.003	2.8411	0.0085***	0.0032	2.7044
α_{Gold}	0.0493***	0.0062	7.9973	0.0737***	0.0114	6.4885
β_{Gold}	0.9493***	0.0052	182.6596	0.9467***	0.0061	154.7888
λ_{Gold}	3.9136***	0.2495	15.687	4.0811***	0.2619	15.5801
γ_{Gold}				-0.0429***	0.0127	-3.3655
θ_1	0.0076*	0.0045	1.6911	0.0069	0.0045	1.5248
θ_2	0.9634***	0.0322	29.9491	0.9631***	0.0375	25.6977
θ_3				0.0023	0.0035	0.6576
λ	6.1875***	0.2855	21.6753	6.3756***	0.3030	21.0397
Akaike	10.522			10.510		
Bayes	10.561			10.554		
Shibata	10.522			10.510		
H-Q	10.536			10.526		
L- L	-20562			-20534		
GO-GARCH Parameters Estimates				**F1**	**F2**	**F3**
ω				0.0332	0.0038	0.0067
α				0.1507	0.0419	0.047
β				0.8269	0.9547	0.9482
Skew				-0.1018	-0.1068	-0.0568
λ				1.1402	1.8972	0.8162
L- L				-20447.6		
No. of Observation				3913		

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. F 1, 2, 3 indicates the set of unobserved underlying factors for basic materials sector index, oil and gold. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***, **,*).

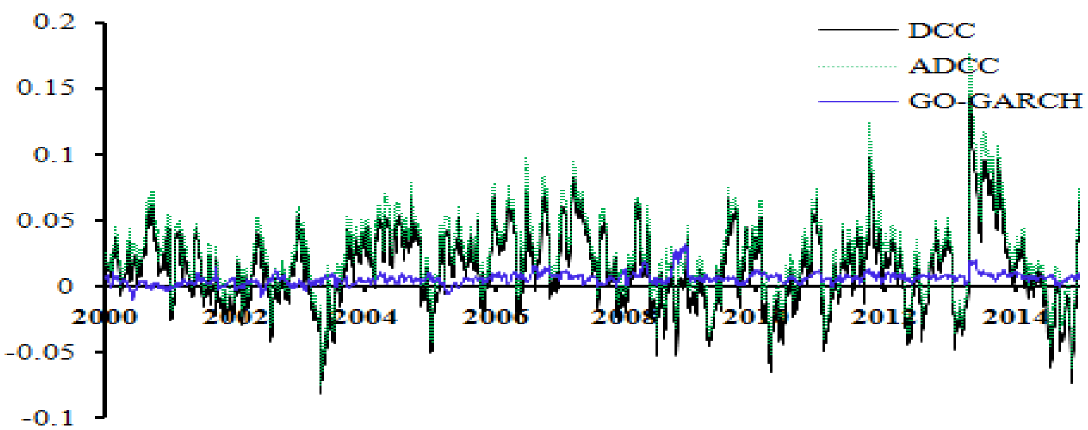
4.3.1.1 Time Varying Conditional Correlations

Figures 4.1a, b depict that the time-varying conditional correlations between basic materials sector stocks and alternative assets. The correlations produced from DCC and ADCC models similar but GO-GARCH model correlations are dissimilar with DCC and ADCC models results. Specifically, the dynamic correlations between basic materials sector stocks and oil pair fluctuate between positive and negative values. These correlations are positive during turbulence time 2007-2009 suggesting that a lack of safe haven opportunity of oil asset for basic materials sector stocks. The dynamic conditional correlations between basic materials sector stocks and gold pair show the same pattern as produced from DCC and ADCC models. By comparing, GO-GARCH model provides different trend in correlations. The conditional correlations cover a range from -0.08 to 0.15 during the entire study period. However, the negative values of correlations are more prominent during turbulence time which indicates that gold maintain its potential safe haven feature for basic materials sector stocks.

a) Dynamic Conditional Correlations: Basic Materials Sector Index and Oil



b) Dynamic Conditional Correlations: Basic Materials Stock Index and Gold



Figures 4.1a, b. Time varying correlations among Basic Materials sector index, Oil and Gold pairs

4.3.1.2 Correlation between Correlations

The correlations produced from all three models are presented in table 4.4. This shows that correlations obtained from DCC and ADCC models are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.2a, b and c. In figures 4.2a, b, along z_1 axis (basic material sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.2c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

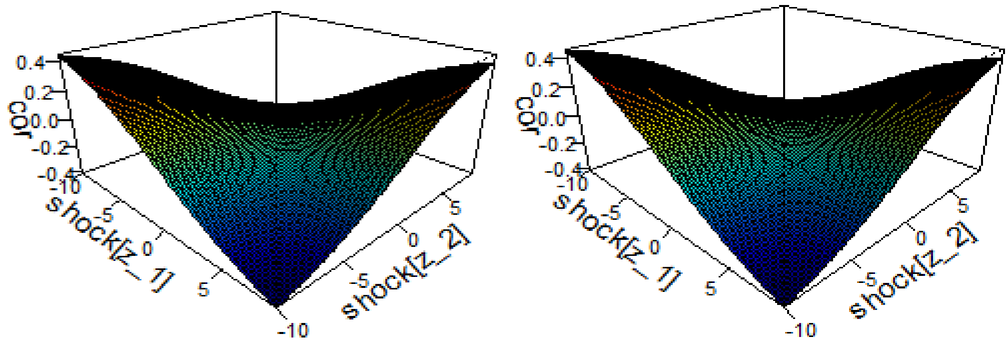
Table 4. 4 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Basic Materials Sector Index/Oil	**Basic Materials Sector Index/Gold**
DCC / ADCC	0.9903	0.9922
DCC / GO-GARCH	0.0908	0.1169
ADCC / GO-GARCH	0.0866	0.1390

Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

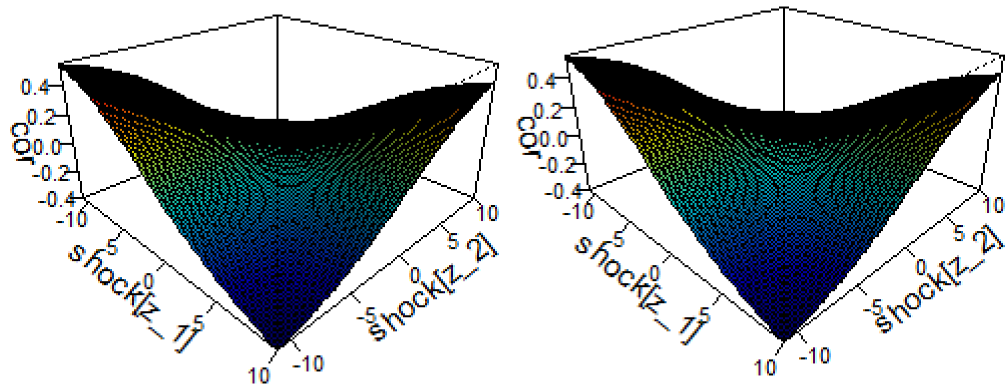
a) News Impact Correlation Surface between Basic Materials Sector Index, Oil and Gold-DCC

i) Oil ii) Gold



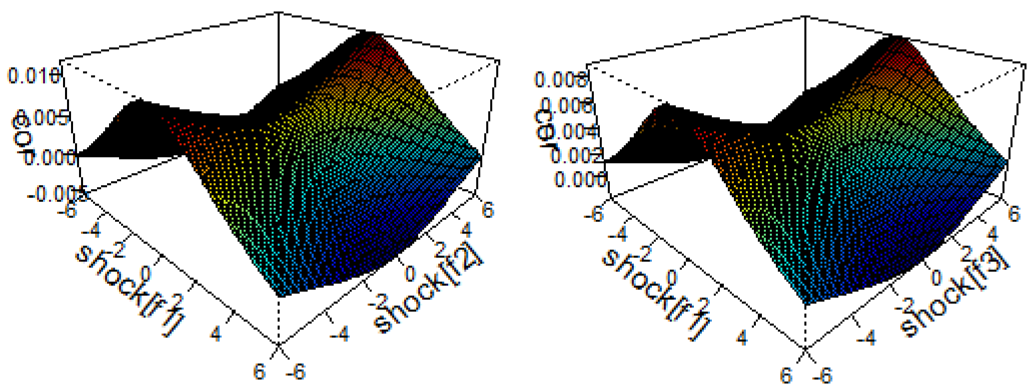
b) News Impact Correlation Surface between Basic Materials Sector Index, Oil and Gold-ADCC

i) Oil ii) Gold



c) News Impact Correlation Surface between Basic Materials Sector Index, Oil and Gold –GO-GARCH

i) Oil ii) Gold



Figures 4.2a, b, c. News impact surface correlations between Basic Materials sector index, oil and gold assets

4.3.1.3 Optimal Hedging Strategy in Basic Materials Sector Index with Oil and Gold Assets

The table 4.5 indicates the hedge ratios among basic materials sector index, oil and gold pairs. The hedge ratios are computed from DCC, ADCC and GO-GARCH models. The DCC produces a mean value of the hedge ratio 0.00319 between basic materials sector index and oil pair indicating that one dollar long position in stocks in basic material sector can be hedged by 0.319 cents investment in oil market. The basic materials sector index and oil pair hedge ratio ranges between -0.15 and 0.10. The ADCC model provides highest average value of hedge ratio 0.01045 providing one dollar long position in basic materials sector stocks can be hedged for 1.05cents in oil market. The average value of hedge ratio computed from GO-GARCH model is 0.38 cents for basic materials sector index and oil pair. By comparing, the average value of the basic materials sector index and gold pair hedge ratio is 1.9 cents for DCC model, 3.31 cents for ADCC model and 0.51 cents for GO-GARCH model, respectively.

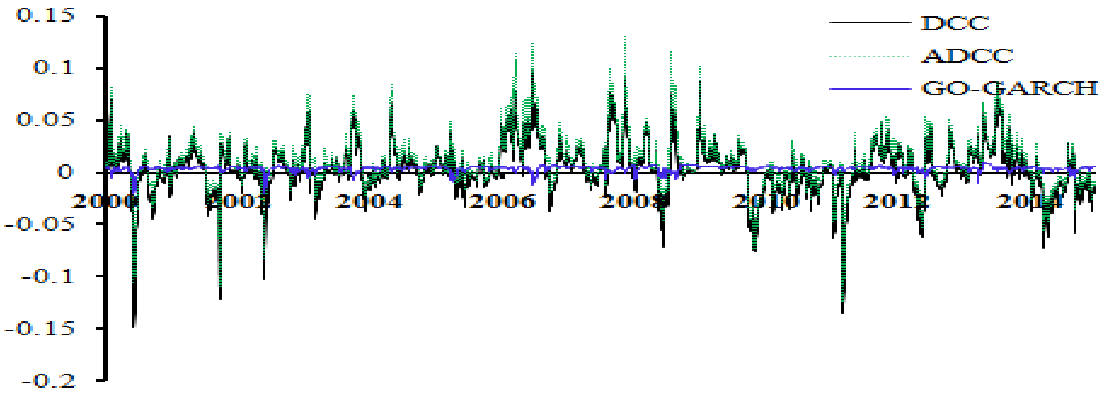
Table 4.5. Hedge Ratio (long / short) Summary For Basic Materials Sector Index

	Mean	Minimum	Maximum
Basic Materials / Oil			
DCC	0.00319	-0.1482	0.09782
ADCC	0.01045	-0.12428	0.13048
GO-GARCH	0.00375	-0.02172	0.0095
Basic Materials / Gold			
DCC	0.01885	-0.16595	0.2529
ADCC	0.03301	-0.16337	0.30463
GO-GARCH	0.00509	-0.09169	0.00914

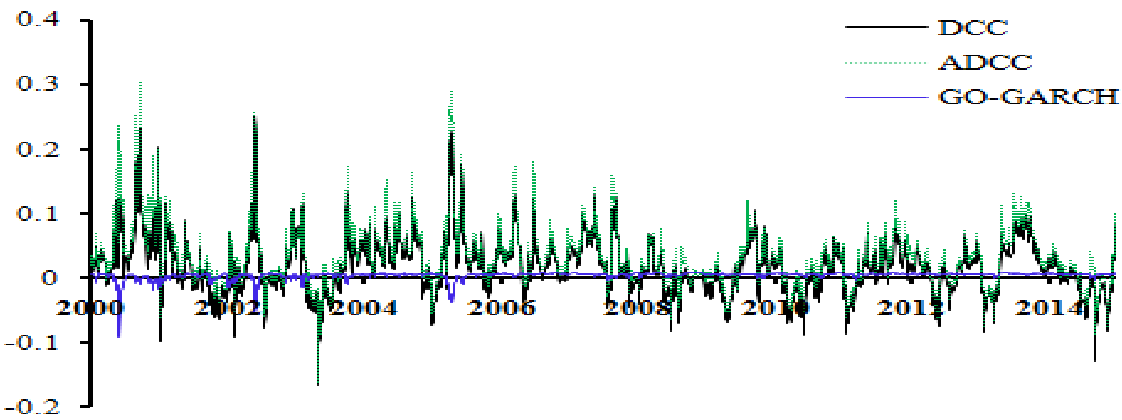
Notes: The table reports the hedge ratios for Basic Materials sector index oil/gold pairs using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stocks is represented by the basic materials sector index.

In addition, figures 4.3a, b show that all multivariate GARCH models produce different trends of hedge ratios over the sample period suggesting that investors must adjust their hedging positions regularly. The hedge ratios obtained from DCC and ADCC models demonstrate the highest variability. But, hedge ratios obtained from GO-GARCH are more stable as compared to DCC and ADCC's hedge ratios. It is important to note that, the dynamic hedge ratios produced from DCC are similar to ADCC hedge ratios. The hedge ratios between basic materials sector index and oil/ gold pairs fluctuate between positive and negative values indicating that investors should regularly update their hedge positions.

a) Optimal Hedge Ratio: Basic Materials Sector Index and Oil



b) Optimal Hedge Ratio: Basic Materials Sector Index and Gold



Figures 4.3a, b. Dynamic hedge ratios among Basic Materials sector index, oil and gold pairs

4.3.1.4 Portfolio Implication of Oil and Gold assets with Basic Materials Sectors Stocks

A portfolio weights summary for Basic Materials sector stocks, oil and gold computed from M-GARCH specifications are reported in Table 4.6. The results computed from DCC model suggest that the optimal allocation weight for investment should be 88.75 cents in basic material sector stocks and remaining 11.25 should be invested oil market. For ADCC model, the average portfolio weight is 0.1117 indicating that for a one-dollar portfolio, 88.8 cents should be invested in basic material sector stocks and 11.2 cents should be invested in oil. Further, a similar result is obtained from GO-GARCH Model. While, the optimal weights for basic materials sector/gold pair is different comparing with basic material sector stocks/oil portfolio. The DCC model reveals that the optimal weight 0.02822, indicating that for a 1 dollar portfolio, 97.2 cents should be invested in basic materials sector stocks and the remaining 2.8 cents should be invested in gold. By comparing, ADCC and GO-GARCH produce similar portfolio weights. Finally, mean values of optimal portfolio weights provide a significant minor difference across all models.

Table 4.6. Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Basic Materials / Oil				
DCC	0.11250	0.01923	1.02050	0.11210
ADCC	0.11170	0.01888	0.92350	0.11040
GO-GARCH	0.11200	0.01868	1.01270	0.10960
Basic Materials / Gold				
DCC	0.02822	0.00489	0.17800	0.02354
ADCC	0.02690	0.00397	0.17320	0.02292
GO-GARCH	0.02685	0.00545	0.16320	0.02176

Notes: The table reports the average optimal weight of oil and gold for Basic Materials sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stocks is represented by the basic materials sector index.

4.3.2 Consumer Services Sector

The regression results obtained from multivariate GARCH models are presented in Table 4.7. Turning to the mean equation, for DCC and ADCC specifications, the estimated coefficient for AR term is statistically significant and positive. For conditional volatility, own conditional ARCH effect (α) is used to measure the short-run persistence. The estimated coefficient for α term is statistically significant indicating the evidence of short-term persistence of conditional volatility. For variance equation, own GARCH effects (β), is clearly important in explaining the volatility as estimated. The estimated coefficient of β is statistically significant providing the evidence of long term persistence. The estimated value of α is less than the estimated coefficient of β value, indicating that own volatility long-term GARCH persistence is greater than own volatility short-term ARCH persistence. These results provide the evidence that investors and portfolio managers will lose their investments for long time while earning the high returns on investment in the short run.

The degree of freedom is denoted by the shape parameter (λ) which indicates that estimated value is 6 for consumer services sector index. By comparing with gold[5], oil has highest estimated values of shape parameter indicating that oil asset consists lighter tail. In literature, Mainik *et al.* (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by abnormal returns originate from assets returns with heavy-tail distribution. If this is so, then the gold asset having heavier tails enhanced diversification benefit as compare to oil asset. Further, the findings for asymmetric effects (γ) in ADCC model

[5] The values of oil and gold assets are all similar for all sectors as reported in Basic Materials sector results

is positive for consumer services sector index, providing the evidence that negative residuals identify the large impact as compared to positive shocks of the similar magnitude. For DCC and ADCC model, the estimated coefficients on θ_1 and θ_2 are also positive for consumer services sector index, but only the estimated coefficient on θ_2 is statistically significant at the 1 % level. The estimated sum values of θ_1 and θ_2 are less than one ($\theta_1 + \theta_2 < 1$), which specify that dynamic conditional correlations are mean reverting. The results for GO-GARCH model such as the long-run persistence (GARCH effect) is greater than short run persistence (ARCH effect) for each factor of consumer services sector index) are consistent with the findings from DCC and ADCC models. In case of model fitted, the DCC model outperforms on the basis of each model selection criterion.

Table 4.7 DCC, ADCC and GO-GARCH Parameters Estimates for Consumer Services Sector Index

	DCC			ADCC		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.1028***	0.0220	4.6625	0.0910***	0.0223	4.0809
a	0.1285***	0.0171	7.5246	0.1318***	0.0172	7.6646
ω	0.1020***	0.0268	3.8143	0.1201***	0.0308	3.9050
α	0.1514***	0.0204	7.4150	0.1141***	0.0176	6.4998
β	0.8181***	0.0244	33.5677	0.8051***	0.0261	30.8488
λ	5.9025***	0.5644	10.4579	6.0519***	0.6041	10.0177
γ				0.0815***	0.0289	2.8214
θ1	0.0077	0.0047	1.6312	0.0072	0.0047	1.5336
θ2	0.9592***	0.0367	26.1419	0.9538***	0.0522	18.2714
θ3				0.0031	0.0051	0.6017
λ	6.6673***	0.3384	19.7034	6.8777***	0.3616	19.0217
Akaike	10.606			10.595		
Bayes	10.644			10.640		
Shibata	10.605			10.595		
H-Q	10.619			10.611		
L- L	-20726			-20701		

GO-GARCH Parameters	**Factor**
ω	0.0392
α	0.1456
β	0.8225
Skew	-0.0554

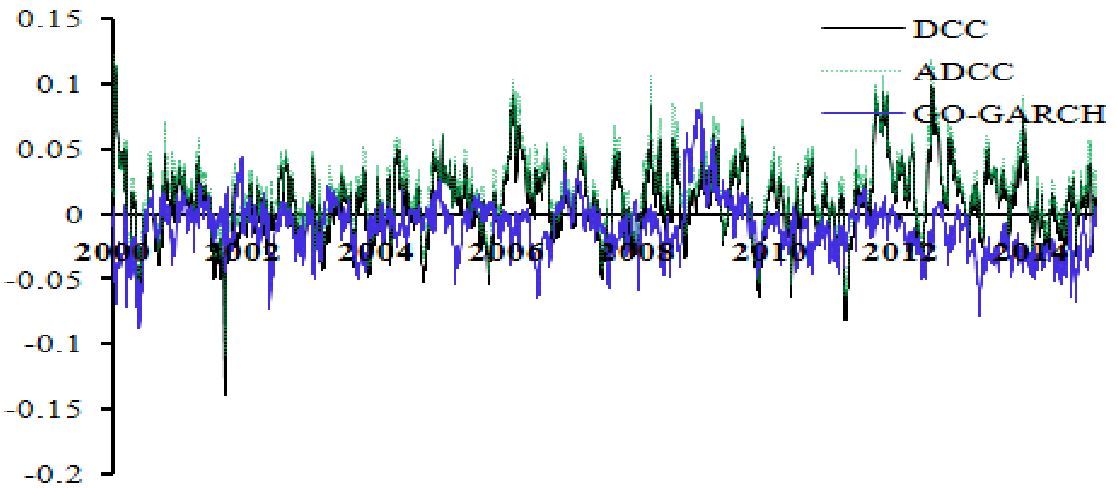
λ	1.5327
L-L	-20617.8
No. of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level 1%, 5% and 10% is shown by an asterisk (***, **,*).

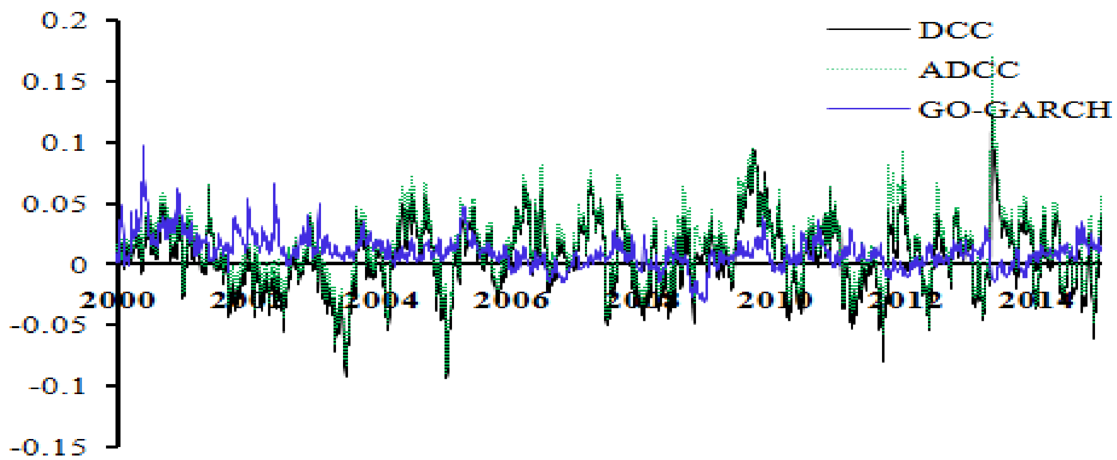
4.3.2.1 Time Varying Conditional Correlations

The time varying conditional correlations, produced from M-GARCH specifications are plotted in figures 4.4a, b. For DCC and ADCC models, conditional correlations are similar between consumer services sector index and oil pair. Although, the time-varying correlations produced from GO-GARCH model are insignificantly different from DCC and ADCC models correlations during the stable and unstable period in financial market. In recession time 2007-2009, these correlations are positive which indicate that oil does not provide the safe haven benefit for stocks. Further, the general trend of conditional correlations between consumer services sector index and gold pair is strongly correlated on average as produced from DCC and ADCC models. But these correlations are strongly different from GO-GARCH model' correlations. The conditional correlations provide a negative pattern during bad times in market, which indicates that gold maintain a potential feature of safe haven asset for stocks in consumer services sector.

a) Dynamic Conditional Correlations: Consumer Services Sector Index and Oil



b) Dynamic Conditional Correlations: Consumer Services Sector Index and Gold



Figures 4.4a, b. Time varying correlations among Consumer Services sector index, Oil and Gold pairs

4.3.2.2 Correlation between Correlations

The correlations produced from all three models are presented in table 4.8. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.5a, b and c.

In figures 4.5a, b, along z_1 axis (consumer services index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.5c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

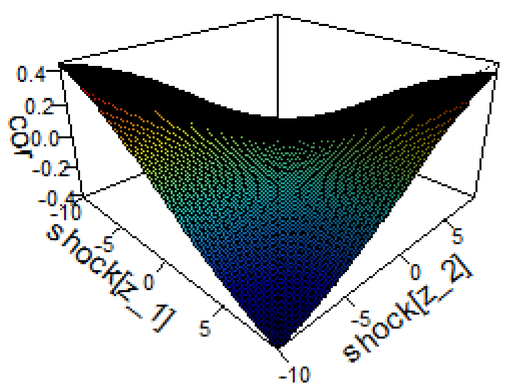
Table 4.8. Correlations between Correlations DCC, ADCC and GO-GARCH Models

	Consumer Services Sector Index/Oil	**Consumer Services Sector Index/Gold**
DCC / ADCC	0.9834	0.9821
DCC / GO-GARCH	0.1374	-0.0384
ADCC / GO-GARCH	0.1463	-0.0622

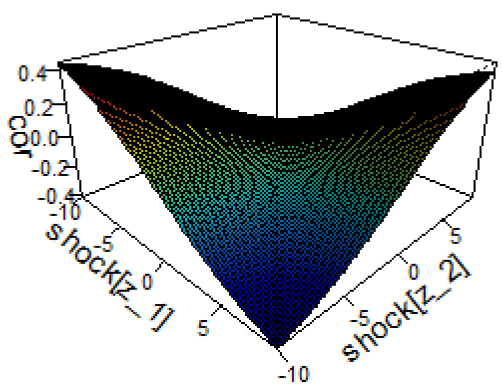
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Consumer Services Sector Index, Oil and Gold-DCC

i) Oil

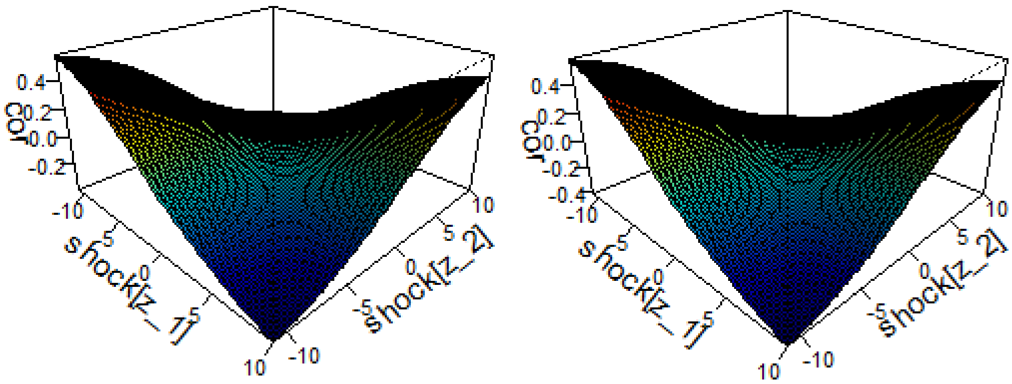


ii) Gold



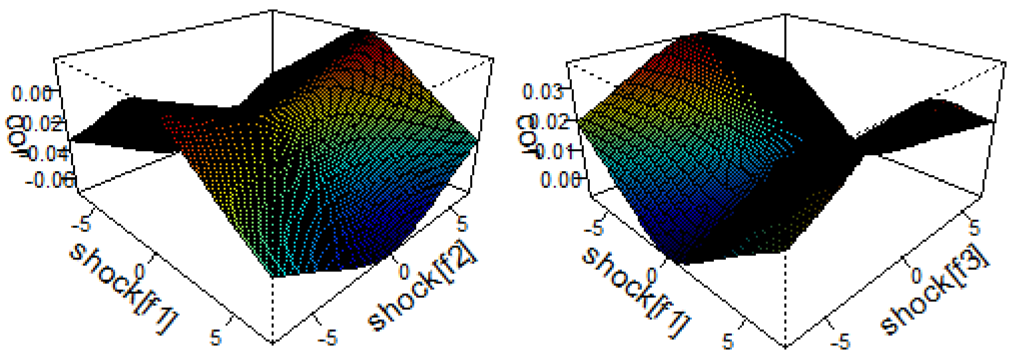
b) News Impact Correlation Surface between Consumer Services Sector Index, Oil and Gold-ADCC

i) Oil ii) Gold



c) News Impact Correlation Surface between Consumer Services Sector Index, Oil and Gold-GO-GARCH

i) Oil ii) Gold



Figures 4.5a, b, c. News impact surface correlations between Consumer Service sector index, oil and gold pairs

4.3.2.3 Optimal Hedging Strategy in Consumer Services Sector Index with Oil and Gold Assets

The hedge ratio (long and short) for consumer services is shown in Table 4.9. The DCC model provides the least average hedge ratio (i.e. 0.00507) for consumer services sector index/oil pairs specifying that one dollar long position in consumer services sector stocks can be hedged for 0.507 cents for short position in oil market. While, one dollar long position in consumer services sector stocks can he hedged for 1.24 cents, 2.15 cents for short position in oil through ADCC and GO-GARCH model, respectively. By comparing, a mean value for consumer services sector index/gold pair is 0.008, indicating that investors should take short position of 0.8 cents in gold asset for one dollar long position in consumer services sector index as obtained from DCC model. For ADCC and GO-GARCH, average values of hedge ratio such as 2.14 cents and 2.44 cents for consumer services sector index/gold pair, which demonstrates that investors should take a short position in gold asset for one dollar long position in consumer services sector index.

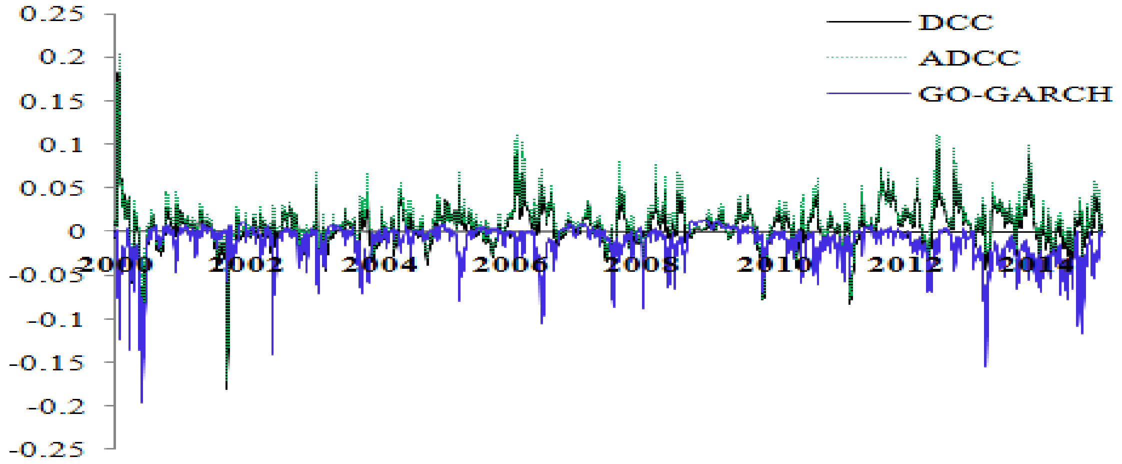
Table 4.9. Hedge Ratio (long/ short) Summary For Consumer Services Sector Index

	Mean	Minimum	Maximum
Consumer Services / Oil			
DCC	0.00507	-0.1812	0.18258
ADCC	0.01236	-0.1714	0.20506
GO-GARCH	0.02148	-0.15504	0.2118
Consumer Services / Gold			
DCC	0.00800	-0.16212	0.2044
ADCC	0.02148	-0.15504	0.2118
GO-GARCH	0.02435	-0.01004	0.8073

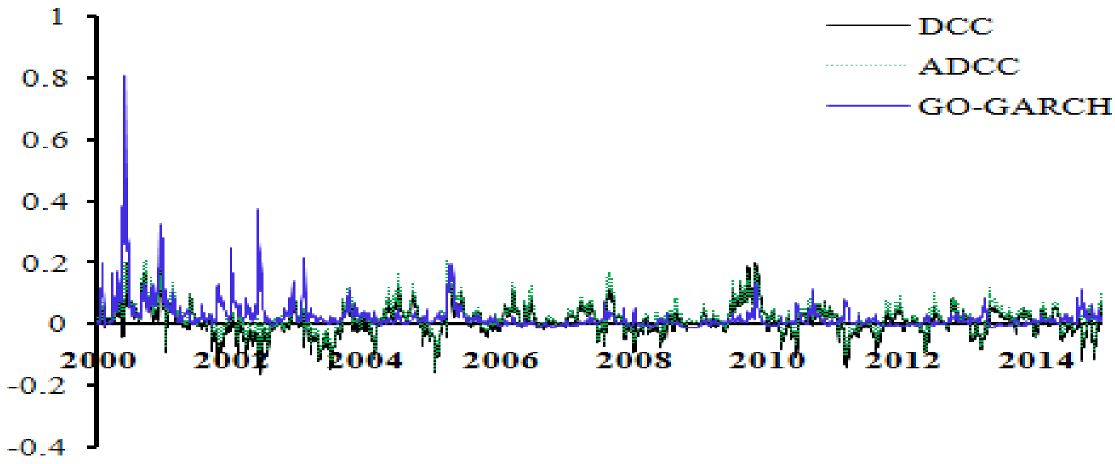
Notes: The table reports the hedge ratios among consumer service sector index and oil/gold pairs using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stock is represented by the consumer service sector index.

Generally, figures 4.6a, b depict the trend of hedge ratios between consumer services sector index and oil/gold pairs. These hedge ratios produced from DCC, ADCC and GO-GARCH models are less volatile on average across the sample period. For DCC and ADCC models, the time varying hedge ratios between consumer services sector index and oil show a positive trend except in the third quarter of 2011. Notice that the positive patterns of hedge ratios indicate that oil acts as a diversifier asset and hedging asset in third quarter of 2011. But, the hedge ratios obtained from GO-GARCH model demonstrate a negative trend during the whole sample period. The hedge ratios produced from DCC are similar to the ones from ADCC model. These ratios fluctuate between positive and negative values indicating that investors should rebalance strongly their positions in oil and gold futures in order to maintain a risk minimizing hedge against consumer service sector stocks. Lastly, the optimal hedge ratios pattern between consumer services sector and gold pairs are significantly similar after 2003 extracted from M-GARCH models. During Global Financial crisis 2007-2009, the hedge ratios between consumer services sector and gold pair shows a negative pattern indicating that a short position should be taken in the first asset and a long position should be taken in the other. Overall, dynamic hedge ratios between consumer services sector and gold pair are less volatile than the hedge ratios between consumer services sector and oil portfolio.

a) Optimal Hedge Ratio: Consumer Services Sector Index and Oil



b) Optimal Hedge Ratio: Consumer Services Sector Index and Gold



Figures 4.6 a, b. Dynamic Hedge Ratios among Consumer services sector index, Oil and Gold pairs

4.3.2.4 Portfolio Implication of oil and gold assets with Consumer Services Sector Index

The portfolio weights for consumer services, oil and gold are summarized in Table 4.10. The portfolio weight computed from DCC model for consumer services sector index-oil portfolio is 0.1126, indicating that for one dollar portfolio, 88.74 cents should be invested in consumer services sector index and 11.26 should be invested in oil. Further, portfolio weights of ADCC are slightly different from the ones produced from GO-GARCH specifications. For instance, DCC provides average weight as 0.02853 for consumer services sector index-gold portfolio, providing that 97.15 cents should be invested in consumer services sector index and remaining 2.85 cents should be invested in gold market. The ADCC and GO-GARCH also produce identical results by comparing with DCC model’s findings however the minimum and maximum values are different in all cases.

Table 4.10 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Consumer Services / Oil				
DCC	0.11260	0.01929	1.04310	0.11360
ADCC	0.11170	0.01879	0.94180	0.11190
GO-GARCH	0.11340	0.02034	1.00860	0.10880
Consumer Services / Gold				
DCC	0.02853	0.00513	0.17760	0.02352
ADCC	0.02722	0.00425	0.17260	0.02287
GO-GARCH	0.02677	0.00181	0.16800	0.02243

Notes: The table reports the average optimal weight of oil and gold for consumer service sector index oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stock is represented by the consumer service sector index

4.3.3 Consumer Goods Sector

The table 4.11 reports the estimated parameters results obtained from DCC, ADCC and GO-GARCH models. In mean equation, the estimated coefficients values measured through DCC and ADCC models for conditional mean (μ) are positive and statistically significant. Additionally, the estimated coefficient value for AR (a) is positive and statistically significant. This shows that past realizations of stock returns in this sector helps to predict the returns in future. The estimated values for parameters α and β indicate that sector returns display a strong persistence in volatility. The statistical significance of parameter (α), for short–term ARCH persistence in mean equation, provides the existence of short-term persistence of volatility. For variance equation, estimated coefficient value is significant for long-term GARCH persistence (β) and also greater than short-term persistence (α), suggests that own volatility long-term GARCH persistence is greater than own volatility short-term ARCH persistence. This shows that investors and portfolio managers will earn a high returns on investment in the short run but they will lose their investments in the long run.

The shape parameters (λ) show the degree of freedom which indicates that the shape of t-distribution approaches to normal as number of degree of freedom reaches to infinity. The value of shape parameters is highest (i.e., 6) for consumer goods sector index. In case of oil and gold assets[6], the highest estimated values of shape parameters are observed for oil asset. Mainik *et al.* (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are

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[6] The values of oil and gold assets also observe similar pattern for all sectors as reported in Basic Materials sector results.

driven by abnormal returns originate from assets returns with heavy-tail distribution. The lowest values of shape parameter of gold indicate that gold with heavier tails provide a better diversification benefits. This also shows the importance of portfolio comprising with mixed assets. The estimated coefficient for asymmetric effects (γ) estimated through ADCC specifications is positive for consumer goods sector index, providing the evidence that returns are more volatile in the presence of negative innovation information (residuals) in comparison to positive shocks of the equal size. For DCC and ADCC models, the estimated coefficients on θ_1 and θ_2 are positive for consumer goods sector index, but only the estimated coefficient on θ_2 is statistically significant at the 1 % level. The estimated sum values of θ_1 and θ_2 are less than one which specifies that dynamic conditional correlations are not constant over time. In case of GO-GARCH model, the results on volatility persistence in considered markets are similar with findings of DCC and ADCC models.

Table 4.11 DCC, ADCC and GO-GARCH Parameters Estimates for Consumer Goods Sector Index

	DCC			**ADCC**		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.0622***	0.0261	2.3809	0.0505*	0.0266	1.9019
a	0.0974***	0.0173	5.6293	0.0993***	0.0173	5.7324
ω	0.1418***	0.0395	3.5937	0.1551***	0.0424	3.6564
α	0.1380***	0.0182	7.5866	0.1098***	0.0176	6.2427
β	0.8314***	0.0225	37.0204	0.8270***	0.0229	36.1101
λ	6.3911***	0.6741	9.4813	6.4333***	0.6910	9.3096
γ				0.0557***	0.0229	2.4380
θ_1	0.0067*	0.0034	1.9494	0.0060*	0.0035	1.6860
θ_2	0.9674***	0.0232	41.7271	0.9648***	0.0333	28.9335
θ_3				0.0028	0.0037	0.7385
λ	6.7442***	0.3500	19.2667	6.9153***	0.3641	18.9954
Akaike	11.001			10.991		
Bayes	11.039			11.036		
Shibata	11.001			10.991		
H-Q	11.014			11.007		
L- L	-21499			-21476		

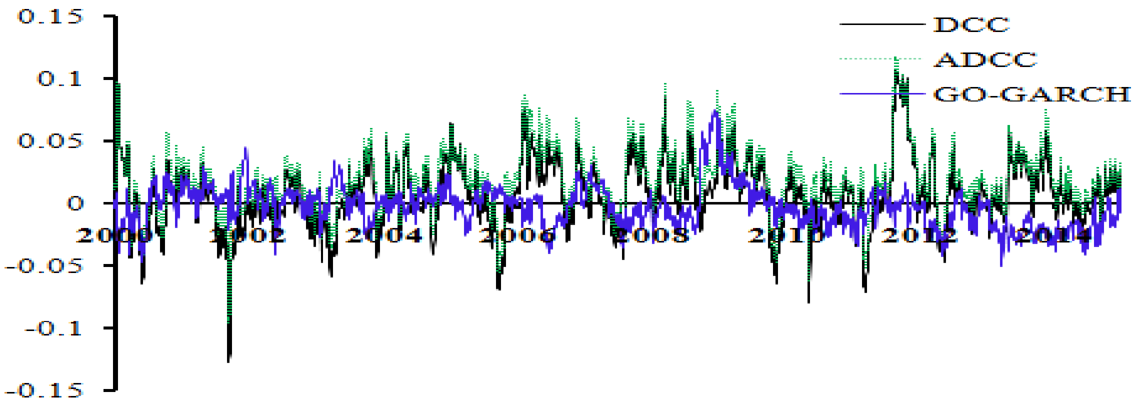
GO-GARCH Parameters	Factor
ω	0.0413
α	0.1363
β	0.8302
Skew	-0.0143
λ	1.7255
L-L	-21399.8
No. of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***, **,*).

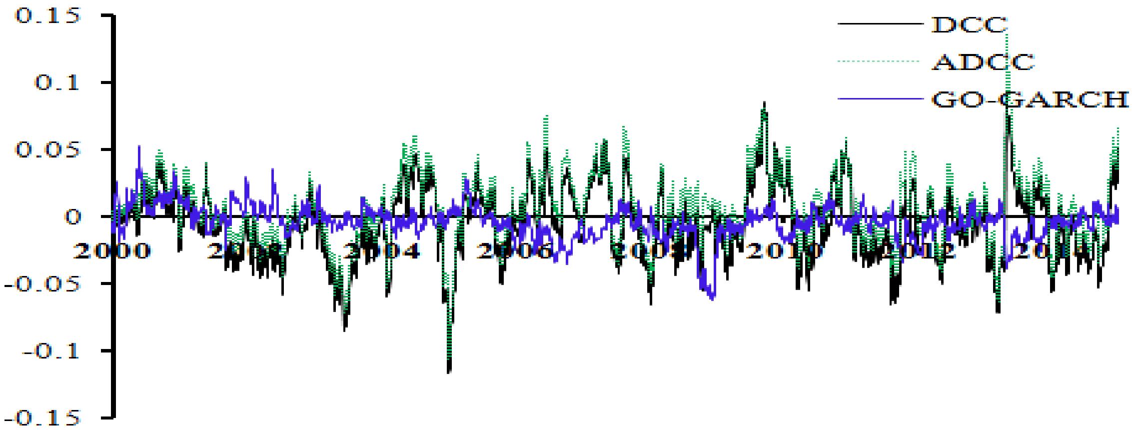
4.3.3.1 Time Varying Conditional Correlations

Figures 4.7a, b show the time varying conditional correlations estimated from DCC, ADCC and GO-GARCH models for consumer goods sector index and oil/gold pairs. DCC model provides the same pattern of conditional correlations compared with ADCC model's correlations. While, correlations produced form GO-GARCH model are less volatile than correlations produced from DCC and ADCC models. Further, a large variation in correlations between consumer goods sector index and oil pair are found between positive and negative values which specify that there is high possibility of diversification benefits of oil in the consumer goods sector stock. Further, the general trend of conditional correlations between consumer services sector index and gold pair are strongly correlated on average, produced from DCC and ADCC models. But these correlations strongly differ from GO-GARCH model' correlations. The interesting insights of these conditional correlations provide a negative pattern during bad times 2007-2009 which indicates that gold provides better safe haven opportunity for consumer services sector stocks.

a) Dynamic Conditional Correlations: Consumer Goods Sector Index and Oil



b) Dynamic Conditional Correlations: Consumer Goods Sector Index and Gold



Figures 4.7a, b. Time varying correlations among Consumer Goods sector index, Oil and Gold pairs

4.3.3.2 Correlation between Correlations

The correlations produced from all three models are presented in table 4.12. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.8a, b and c. In figures 4.8a, b, along z_1 axis (consumer goods sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.8c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

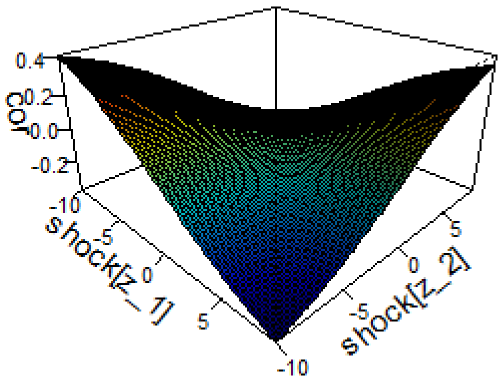
Table 4.12 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Consumer Goods Sector /Oil	Consumer Goods Sector /Gold
DCC / ADCC	0.9831	0.9835
DCC / GO-GARCH	0.0261	-0.0712
ADCC / GO-GARCH	0.0571	-0.1103

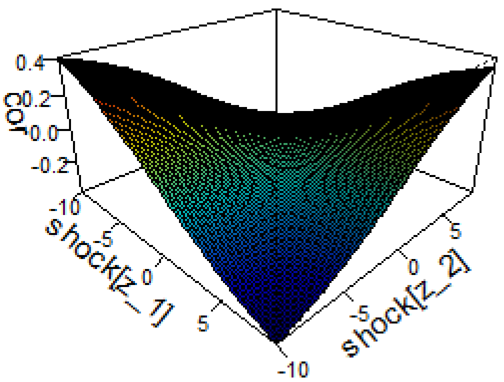
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Consumer Goods Sector Index, Oil and Gold-DCC

i) Oil

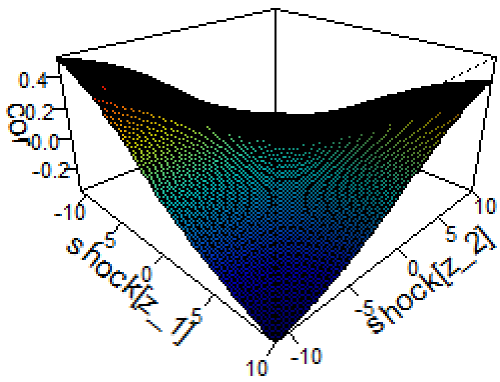


ii) Gold

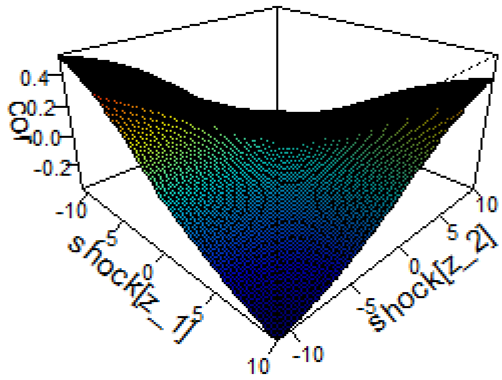


b) News Impact Correlation Surface between Consumer Goods Sector Index, Oil and Gold - ADCC

i) Oil

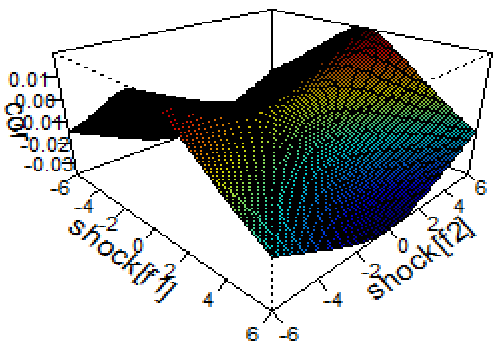


ii) Gold

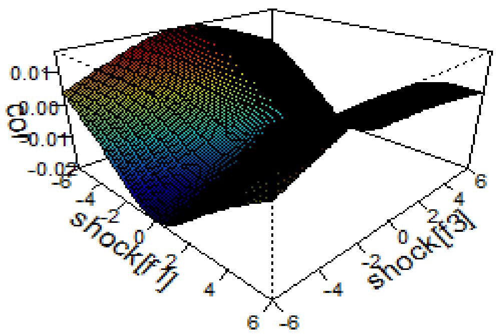


c) News Impact Correlation Surface between Consumer Goods Sector Index, Oil and Gold-GO-GARCH

i) Oil



ii) Gold



Figures 4.8a, b, c. News impact surface correlations between Consumer Goods sector index, oil and gold assets

4.3.3.3 Optimal Hedging Strategy in Consumer Goods Sector Index with Oil and Gold Assets

Table 4.13 shows the hedging position for consumer goods sector stocks with oil and gold assets as computed from DCC, ADCC and GO-GARCH models. In order to minimize risk, a long (buy) position of one dollar in consumer goods sector stocks should be hedge by short (sell) position of 0.62 cents in oil market. The average hedge ratio computed ADCC model shows a large variation as compared to GO-GARCH model for consumer goods sector index and oil pair. On comparison, the average value of hedge ratio for the consumer goods sector index and gold pair is negative i.e. -0.99 cents for DCC model, 0.89 cents for ADCC model and 0.13 cents for GO-GARCH model. The negative value indicates that these pairs are negatively correlated. This also reveals that investors can take hedge position either selling position or buying position in both assets.

Table 4.13 Hedge Ratio Summary for Consumer Goods Sector Index

	Mean	Minimum	Maximum
Consumer Goods / Oil			
DCC	0.00618	-0.17030	0.17591
ADCC	0.01579	-0.15010	0.18843
GO-GARCH	-0.00726	-0.11900	0.01511
Consumer Goods / Gold			
DCC	-0.00985	-0.28195	0.20660
ADCC	0.00892	-0.26870	0.19400
GO-GARCH	0.00132	-0.02454	0.45540

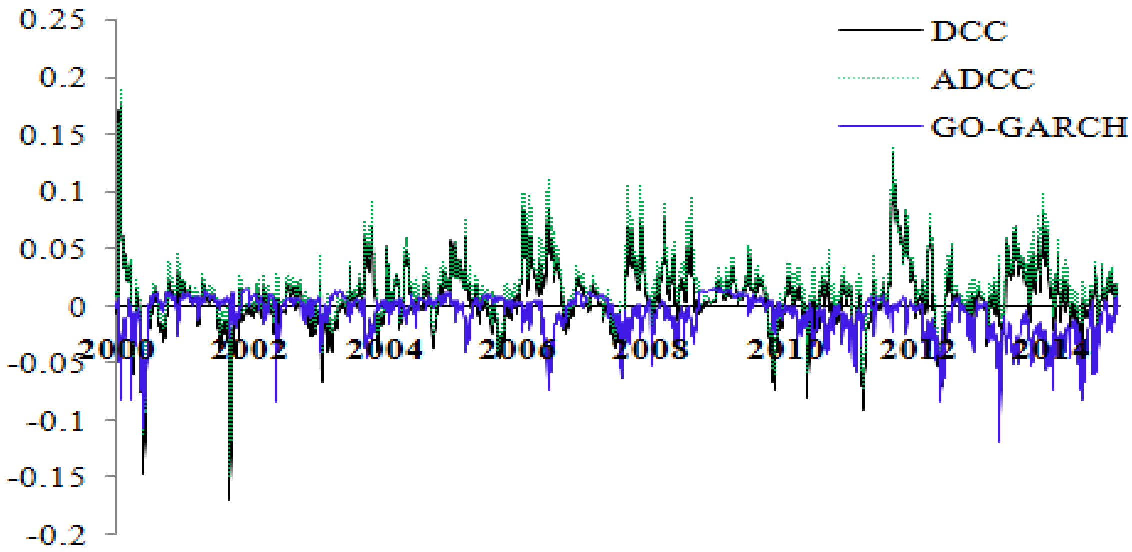
Notes: The table reports the hedge ratios for consumer goods sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stock is represented by consumer goods sector index.

The time varying hedge ratios trend between consumer goods sector index and oil/gold pairs are shown in figures 4.9a, b. The hedge ratios between consumer goods sector index and oil pair are changing from one period to another among positive and negative values. The DCC and ADCC models provide the similar patterns of hedge ratios. By comparing, GO-GARCH specification hedge ratios are uncorrelated with another two models. For DCC and ADCC models, the hedge ratios between consumer goods sector index and oil pair show a negative trend in first quarter indicating that oil provide a scope of hedge asset. The hedge ratios from both these models signify an average positive trend during 2004 to 2014 including the global crisis period 2007-

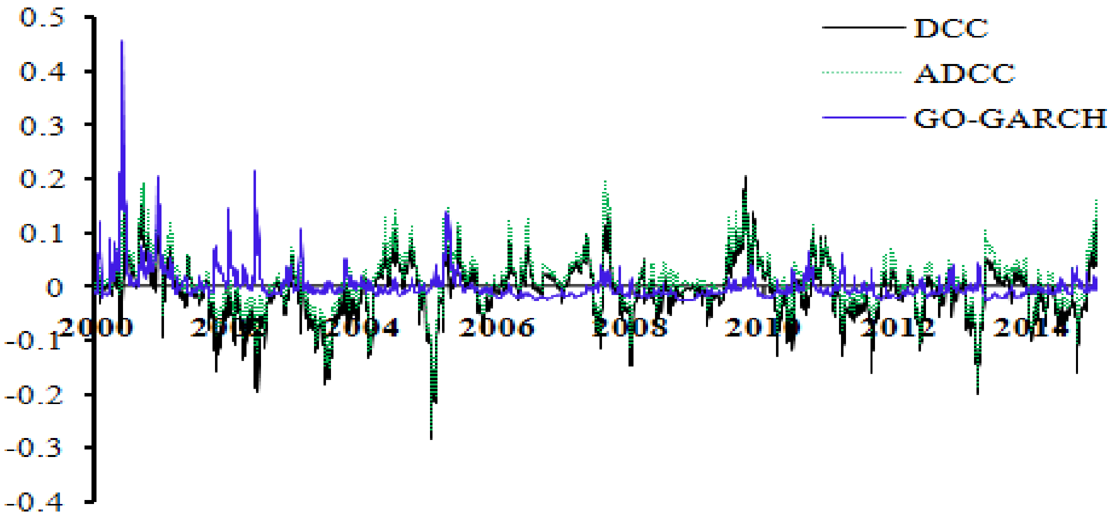
2009. On the contrary, the hedge ratios produced from GO-GARCH model shows a negative trend in values across the study period suggesting that selling position should be taken in the consumer goods sector stocks and a buying position should be taken in oil asset.

Moreover, the time varying hedge ratios between consumer goods sector index and gold pair are presented based on daily frequencies for the whole sample period. The three different multivariate GARCH models are compared which show a dissimilar pattern in hedge ratios between consumer goods sector index and gold pair. Over, the whole study time, the dynamic hedge ratios obtain through DCC and ADCC models are strongly correlated with each other and are uncorrelated with hedge ratios as estimated through GO-GARCH model. During the financial crisis 2007-2009, the hedge ratios produced from all models between consumer goods sector index and gold pair show a negative pattern in values which indicate that, investors should take a selling position in stocks and a buying position in gold asset.

a) Optimal Hedge Ratio: Consumer Goods Sector index and Oil



b) Optimal Hedge Ratio: Consumer Goods Sector Index and Gold



Figures 4.9a, b. Dynamic Hedge Ratios among Consumer Goods sector index, Oil and Gold pairs

4.3.3.4 Portfolio Implication of oil and gold assets with Consumer Goods Sector Index

The summary statistics for optimal portfolio weights computed from DCC, ADCC and GO-GARCH models are reported in Table 4.14. For DCC and GO-GARCH model, the mean value for the consumer goods sector index/oil portfolio is 0.11250, suggesting that for one dollar portfolio, 88.75cents should be invested in consumer goods sector stocks and 11.25 cents should be invested in oil asset. The ADCC model provides a slightly dissimilar result but large difference is found in minimum and maximum values. In case of consumer goods sector index/gold portfolio, the optimal portfolio weight is 0.02904 as measured through DCC model. This means that, for one dollar portfolio, investors should invest 2.90 cent in gold and remaining 97.10 in consumer goods sector stocks. Nevertheless, the ADCC and GO-GARCH models provide average values of 0.02760 and 0.02737 for portfolio weights, respectively.

Table 4.14 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Consumer Goods / Oil				
DCC	0.11250	0.01895	1.03440	0.11310
ADCC	0.11140	0.01847	0.93160	0.11140
GO-GARCH	0.11270	0.01948	1.01420	0.10940
Consumer Goods / Gold				
DCC	0.02904	0.00529	0.17900	0.02378
ADCC	0.02760	0.00440	0.17320	0.02308
GO-GARCH	0.02737	0.00478	0.16950	0.02262

Notes: The table reports the average optimal weight of oil and gold for an oil-consumer goods sector index and gold-consumer goods sector index portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the consumer goods sector index.

4.3.4 Financial Sector

The parameters for financial sector index estimated through multivariate GARCH models are provided in Table 4.15. The coefficients for conditional mean (μ) measured through DCC and ADCC models are positive and statistically significant. The estimated coefficients for autoregressive term (AR) are positive and statistically significant in mean equation. This mean that past realizations of returns help in forecasting the future stock returns. The ARCH term (α) estimated coefficients are significant indicating the evidence of short-term persistence of conditional volatility. For long-term own GARCH persistence in variance equation, the estimated coefficient of β is statistically significant providing the evidence of long-term persistence of volatility which is also greater than short-term persistence (α). The statistically significance of α and β indicates the evidence of volatility clustering. The sum values of both parameters are less than one providing the evidence that volatilities shocks are different in magnitude. In case of ADCC model, the estimated coefficient for the asymmetric effects (γ) is positive providing the evidence that negative innovations (bad news) in returns tend to increase the volatility more than positive innovations (good news) of the equal size.

Further, the lowest estimated values of shape parameter (λ) are observed (i.e., 4) for financial sector index and gold[7]. In case of oil asset, the estimated values are highest with the lighter tails. This means that oil with lighter tails will not provide portfolio benefit as comparison to gold asset. These findings signify the importance to mix assets portfolio with gold asset. The estimated coefficient value of θ_1 and θ_2 are

[7] The values of oil and gold assets are similar for all sectors as reported in Basic Materials sector results.

positively significant but only θ_2 is significant at the 1% level. The sum value of θ_1 and θ_2 is less than one which specifies that the dynamic conditional correlations among financial sector index, oil/gold pairs are not constant over the time. In case of GO-GARCH model, the volatility persistence results indicate a long-term persistence of volatility is greater than short-term persistence. These results coincide with findings of DCC and ADCC specifications in these markets. For model selection criterion, each diagnostic results show that DCC-GARCH is fitted model.

Table 4.15 DCC, ADCC and GO-GARCH Parameters Estimates for Financial Sector Index

	DCC			ADCC		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.1185***	0.0214	5.5447	0.1059***	0.0213	4.9850
a	0.1070***	0.0176	6.0716	0.1139***	0.0177	6.4430
ω	0.1140***	0.0337	3.3874	0.1503***	0.0468	3.2136
α	0.1911***	0.0284	6.7339	0.1434***	0.0217	6.6018
β	0.7980***	0.0301	26.4766	0.7679***	0.0376	20.4061
λ	4.3006***	0.3230	13.3133	4.3145***	0.3248	13.2825
γ				0.1400***	0.0472	2.9671
θ1	0.0115**	0.0056	2.0631	0.0121**	0.0055	2.2004
θ2	0.9086***	0.0623	14.5911	0.9023***	0.0636	14.1865
θ3				0.0006	0.0065	0.0858
λ	5.8936***	0.2741	21.4981	6.0283***	0.2856	21.1084
Akaike	10.701			10.690		
Bayes	10.740			10.735		
Shibata	10.701			10.690		
H-Q	10.715			10.706		
L- L	-20913			-20888		

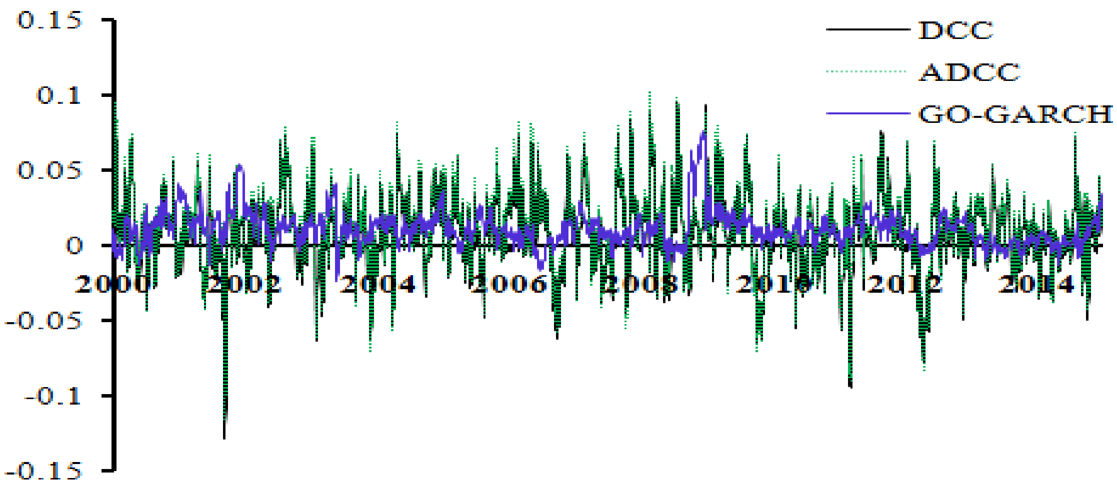
GO-GARCH Parameters Estimates	**Factor**
ω	0.0435
α	0.1805
β	0.7946
Skew	-0.0164
λ	0.8811
L- L	-20789.7
No. of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***, **,*).

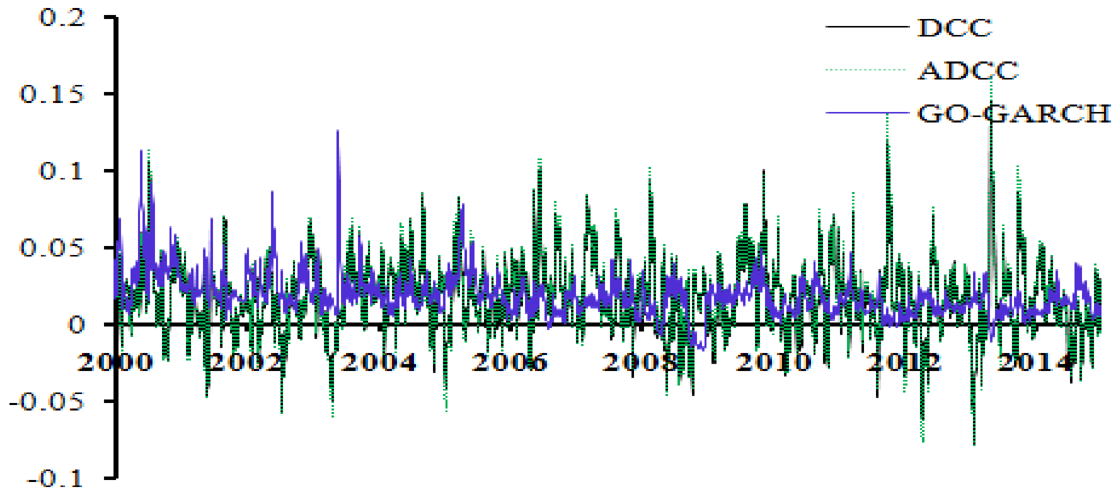
4.3.4.1 Time Varying Conditional Correlations

Turning to the correlations, figures 4.10a, b show the dynamic correlations estimated through M-GARCH models for financial sector index and oil/gold pairs. The conditional correlations obtained from DCC coincide with ADCC model's correlations. The conditional correlations produced form GO-GARCH model are less volatile than correlations generated through DCC and ADCC models. Moreover, these correlations are more dominant to positive values than negative trend for financial sector index and oil pair. On other side, it is clear that positive associations are more dominant than negative correlations between financial sector index and gold pair which are produced from all models. In addition, a negative pattern in dynamic correlations observed during the financial crisis 2007-2009, strengths gold's status as a safe haven asset for investment.

a) Dynamic Conditional Correlations: Financial Sector Index and Oil



b) Dynamic Conditional Correlations: Financial Sector Index and Gold



Figures 4.10a, b. Time varying correlations among Financial sector index, Oil and Gold pairs

4.3.4.2 Correlation between Correlations

The correlations produced from all three models are shown in table 4.16. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.11a, b and c. In figures 4.11a, b, along z_1 axis (financial sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.11c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

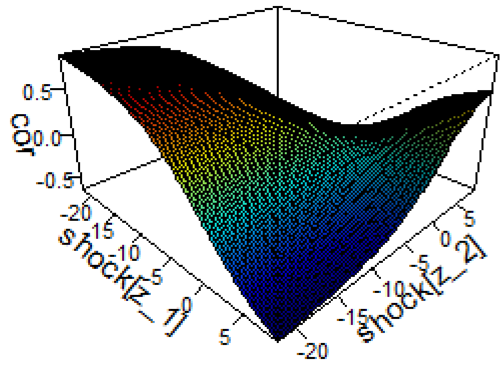
Table 4.16 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Financial Sector / Oil	Financial Sector / Gold
DCC / ADCC	0.9958	0.9961
DCC / GO-GARCH	0.0569	0.0578
ADCC / GO-GARCH	0.0522	0.0509

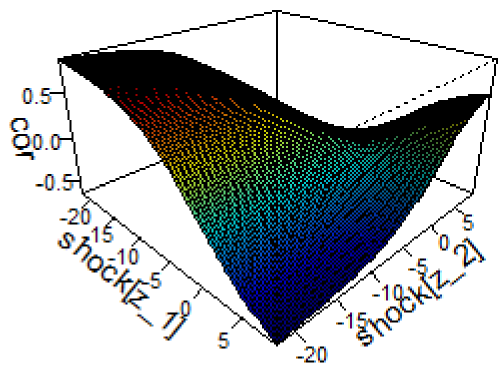
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Financial Sector Index, Oil and Gold-DCC

i) Oil

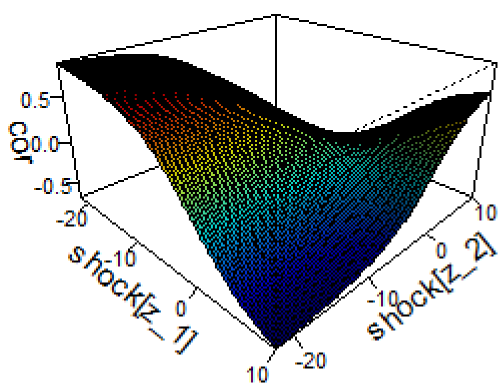


ii) Gold

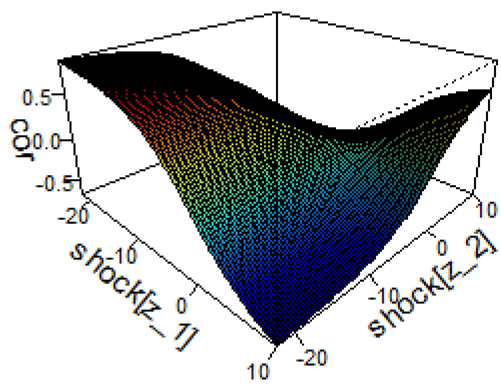


b) News Impact Correlation Surface between Financial Sector Index, Oil and Gold-ADCC

i) Oil

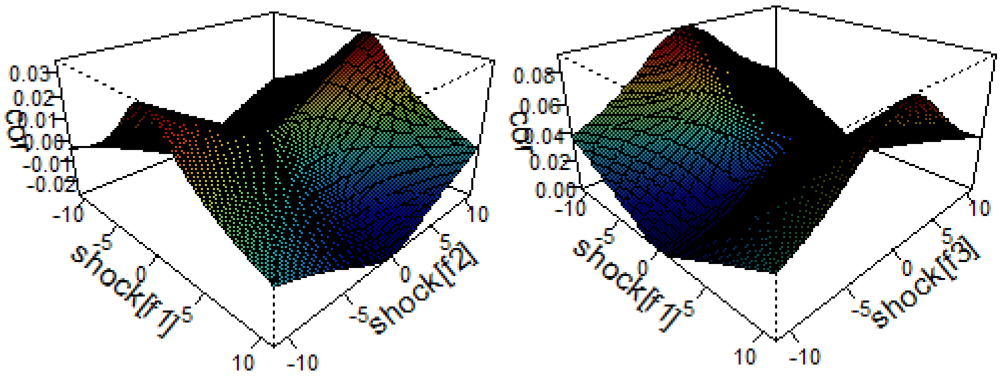


ii) Gold



c) News Impact Correlation Surface between Financial Sector Index, Oil and Gold-GO-GARCH

i) Oil ii) Gold



Figures 4.11a, b, c. News impact surface correlations between financial sector index, oil and gold pairs

4.3.4.3 Optimal Hedging Strategy in Financial Sector Index with Oil and Gold Assets

The average value of hedge ratio between financial sector index and oil pair is 0.66 cents for the DCC model indicating that dollar one long position can be hedged for 0.66 cents in the oil market (Table 4.17). By comparison, the mean value of hedge ratio between financial sector index and oil pair is 0.93 cents as computed from the ADCC model and 0.55 cents by using the GO-GARCH model. For DCC model, the mean value remains 2.3 cents of hedge ratio for financial sector index and gold pair suggesting that one dollar long position can be hedged for 2.3 cents in the gold market. The hedge ratios between financial sector index and gold pair are 3.14 cents and 4.12 cents, respectively as obtained through ADCC and GO-GARCH specifications.

Table 4.17 Hedge Ratio Summary For Financial Sector

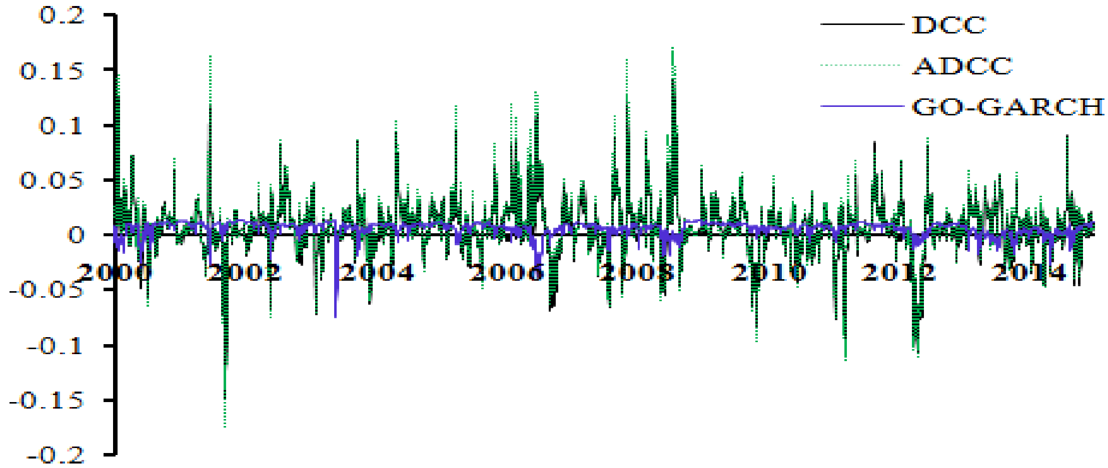
	Mean	Minimum	Maximum
Financials / Oil			
DCC	0.00661	-0.15000	0.14130
ADCC	0.00926	-0.17391	0.16990
GO-GARCH	0.00549	-0.07602	0.01300
Financials / Gold			
DCC	0.02976	-0.19912	0.42210
ADCC	0.03138	-0.25056	0.53430
GO-GARCH	0.04123	-0.00543	1.09300

Notes: The table reports the hedge ratios for financial sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stock is represented by the financial sector index.

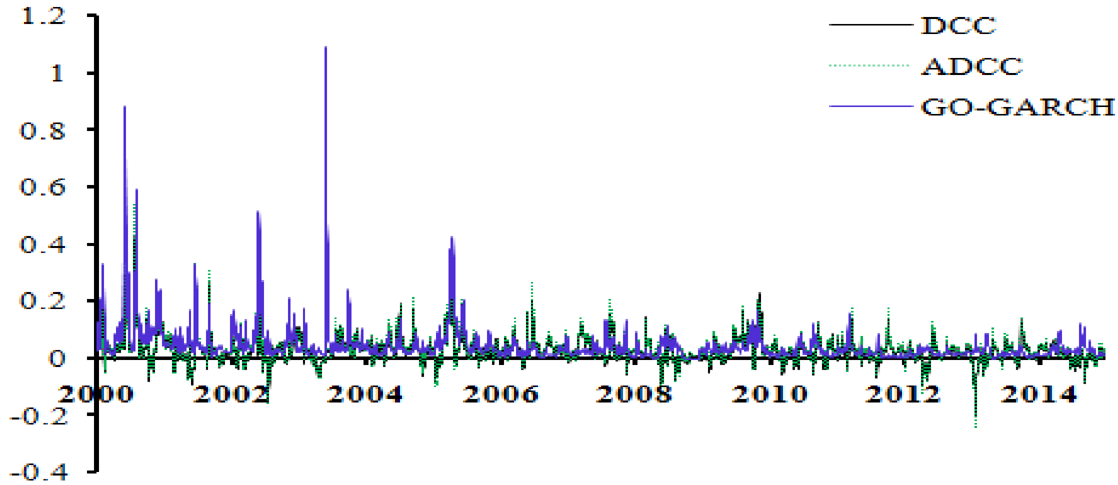
Figures 4.12 a, b present the optimal hedge ratios trend between financial sector index and oil/gold pairs. These hedge ratios provide an upward and downward pattern during the sample period. The time varying hedge ratios produced from DCC and ADCC models show a similar trend but hedge ratios obtained from GO-GARCH specification are uncorrelated with DCC and ADCC models. On average, a positive trend in hedge ratios scrutinizes during 2004 to 2014 including the Global Crisis period 2007-2009, suggesting that oil act as a diversifier asset from 2004 to 2014. Contrary, the hedge ratios produced from GO-GARCH model shows a negative trend in values across the study period which indicate that investors should take a selling position in first asset and a buying position in the other.

Moreover, the time varying hedge ratios between financial sector index and gold pair are presented based on daily frequencies. The three different multivariate GARCH models are compared which provide a dissimilar pattern in hedge ratios. The DCC and ADCC's hedge ratios are strongly correlated with each other but the hedge ratios obtained from GO-GARCH model are uncorrelated with DCC and ADCC hedge ratios only from 2000 to 2003.

a) Optimal Hedge Ratio: Financial Sector Index and Oil



b) Optimal Hedge Ratio: Financial Sector Index and Gold



Figures 4.12a, b. Dynamic Hedge Ratios among Financial Sector Index, Oil and Gold pairs

4.3.4.4 Portfolio Implication of oil and gold assets with Financial Sector Index

The conditional volatilities computed form DCC, ADCC and GO-GARCH models are used to construct the optimal portfolio weights. Table 4.18 shows that adding oil and gold asset into diversified portfolio of stocks in financial sector improves the risk-adjusted returns. The average weight i.e. 0.11230 as computed from DCC model for financial sector/oil portfolio signify that for one dollar portfolio, 88.77 cents should be invested in financial sector stocks and 11.23 cents should be invested in oil. In case of financial sector/gold portfolio, for dollar one portfolio, investors should make an investment of 97.03 cents in financial sector stocks and remaining, 2.97 cents should be invested in gold market. On comparison, portfolio weights obtained from ADCC and GO-GARCH models are slightly different from each other in portfolio consisting of financial sector index/oil and gold pairs. These results reveal that portfolio consisting only stocks would display a greater risk then mixed assets portfolio e.g. stock-oil/gold portfolio.

Table 4.18 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Financials / Oil				
DCC	0.11230	0.01845	1.05400	0.11320
ADCC	0.11210	0.01818	0.95000	0.11190
GO-GARCH	0.11150	0.01876	1.00500	0.10880
Financials / Gold				
DCC	0.02793	0.00485	0.17540	0.02335
ADCC	0.02699	0.00425	0.17540	0.02291
GO-GARCH	0.02625	-0.00181	0.16680	0.02211

Notes: The table reports the average optimal weight of oil and gold for an oil-financial sector index and gold-financial sector index portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the financial sector index.

4.3.5 Health Care Sector

The dynamic conditional correlations produced from DCC, ADCC and GO-GARCH are shown in Table 4.19. First, the estimated coefficients in mean equation for conditional mean (μ) are positively significant. In case of autoregressive term, the estimated coefficients are statistically significant and positive. For conditional volatility equation, own conditional ARCH effect (α) is used to measure the short-run persistence. The estimated coefficients for own conditional ARCH effect are statistically significant indicating the evidence of short-term persistence of conditional volatility. For variance equation, own GARCH effects (β), are clearly important to explain the volatility. The estimated coefficients of own GARCH effects (β) are statistically significant which provide the evidence of long term persistence behavior in variances. The estimated α value is less than the estimated coefficient of β value, indicating that own volatility long-term GARCH persistence is greater than own volatility short-term ARCH persistence. These results suggest that investors will lose the returns of investment in this sector in the long run and only earn higher returns in the short run, which coincide with previous findings of Rahim & Mashi (2016).

Moreover, the estimated coefficient for the asymmetric effects (γ) is positive for Health care sector, providing the evidence that negative innovations in returns tend to increase the conditional volatility (variance) in future more than the positive innovations in returns of the same magnitude. Further, the shape parameter (λ) shows the degree of freedom which indicates that the shape of t-distribution approaches to normal as number of degree of freedom reaches to infinity. The estimated coefficients values (i.e., 5) of shape parameter (λ) are less than the value of oil asset[8]. The highest estimated values of oil are found for shape parameter (i.e., 6), while, the estimated coefficient of shape parameter report a lowest value for gold asset. This shows that gold having lower tail offer superior portfolio benefit as compared to oil asset suggesting the importance of portfolio consisting of mixed assets.

For DCC and ADCC models, the estimated coefficients on θ_1 and θ_2 are positive for Health Care sector index, oil/gold pairs but only the estimated coefficient on θ_2 is statistically significant at 1% level. The estimated sum values of θ_1 and θ_2 are less than one, suggesting that dynamic conditional correlations are mean reverting. In case of GO-GARCH model, long term volatility persistence (GARCH effects) is more than short term persistence (ARCH effects). These findings are similar to the results obtained from DCC and ADCC models. Finally, each diagnostic test for model selection indicates that the DCC model is best fitted model among others.

Table 4.19 DCC, ADCC and GO-GARCH Parameters Estimates for Health Care Sector Index

	DCC			**ADCC**		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.0731***	0.0203	3.6070	0.0702***	0.0209	3.3624
a	0.0934***	0.0172	5.4358	0.0936***	0.0172	5.4441
ω	0.0861***	0.0246	3.5003	0.0872***	0.0247	3.5331
α	0.1674***	0.0226	7.4096	0.1589***	0.0231	6.8665
β	0.8225***	0.0240	34.3211	0.8216***	0.0239	34.4436
λ	4.8183***	0.3473	13.8730	4.8297***	0.3501	13.7961
γ				0.0176	0.0228	0.7741
θ_1	0.0072*	0.0038	1.9183	0.0067*	0.0039	1.7382
θ_2	0.9826***	0.0134	73.2507	0.9836***	0.0137	71.6515
θ_3				0.0008	0.0012	0.6735
λ	6.0797***	0.2681	22.6802	6.2113***	0.2755	22.5479
Akaike	10.662			10.654		
Bayes	10.700			10.699		

[8] The values of oil and gold assets are all similar for all sectors as reported in Basic Materials sector results.

Shibata	10.662	10.654
H-Q	10.675	10.670
L- L	-20835	-20817

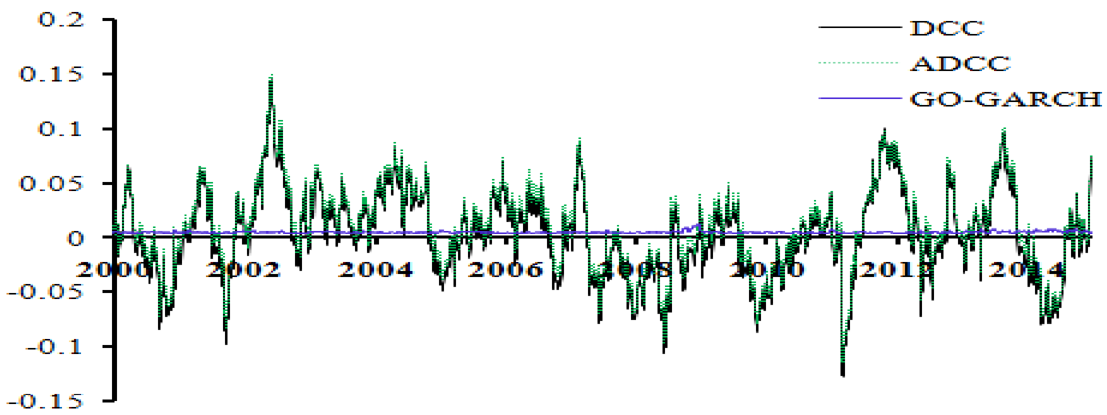
GO-GARCH Parameters Estimates	**Factor**
ω	0.0347
α	0.1605
β	0.8195
Skew	-0.0114
λ	1.2465
L- L	-20751.8
No.of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***, **,*).

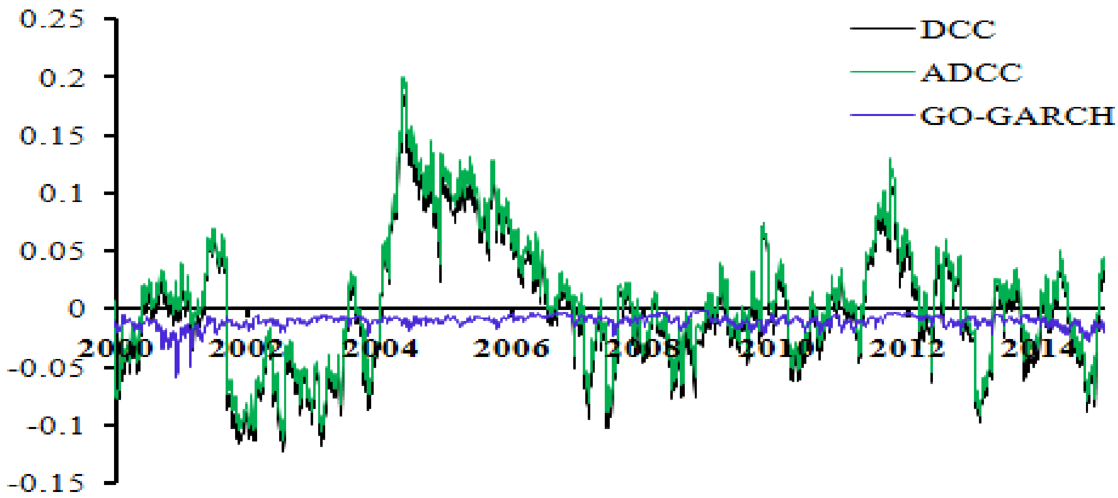
4.3.5.1 Time Varying Conditional Correlations

Figures 4.13a, b show the time varying correlations plots for health care sector index and oil/gold pairs, estimated through three different multivariate models namely DCC, ADCC and GO-GARCH models. It is interesting to note that all models show a different pattern of correlations for all pairs during the study period. Consequently, conditional correlations estimated through DCC model are highly correlated with ADCC model's correlations. Whereas, conditional correlations produced from GO-GARCH model are uncorrelated with DCC and ADCC model's correlations, which shows a least volatile trend. However, there is no clear constant decrease and increase in correlations for DCC and ADCC models. But, GO-GARCH model produces mostly a constant trend in conditional correlations for health care sector index and oil pair. The conditional correlations produced from DCC and ADCC models are significantly negative during the 2000-2001 bubble, Global Financial crisis 2007-2009 and European Debt crisis 2011-2012. These correlations are moving between negative and positive values for health care sector index and gold pair. The DCC model produces a significant highest negative value i.e. -0.12 in 2002 and ADCC shows a significant highest positive value i.e. 0.20 for correlations in 2004. While, weak positive values of correlations are produced through GO-GARCH model. Finally, negative trend in correlations indicate that oil and gold act as safe haven assets during the financial crisis 2007-2009.

a) Dynamic Conditional Correlations: Health Care Sector Index and Oil



b) Dynamic Conditional Correlations: Health Care Sector Index and Gold



Figures 4.13a, b. Time varying correlations among Health Care sector index, Oil and Gold pairs

4.3.5.2 Correlation between Correlations

The correlations produced from all three models are shown in table 4.20. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.14a, b and c. In figures 4.14a, b, along z_1 axis (health care sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.14c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

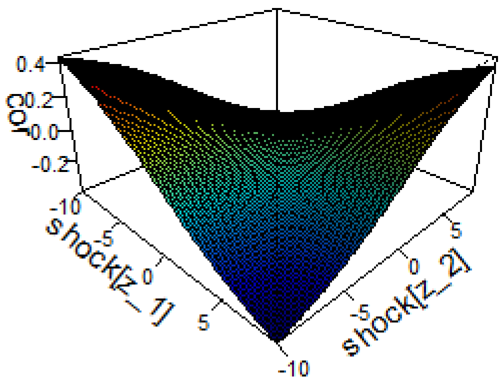
Table 4.20 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Health Care Sector / Oil	**Health Care Sector / Gold**
DCC / ADCC	0.9976	0.9985
DCC / GO-GARCH	-0.1054	0.1140
ADCC / GO-GARCH	-0.1033	0.1174

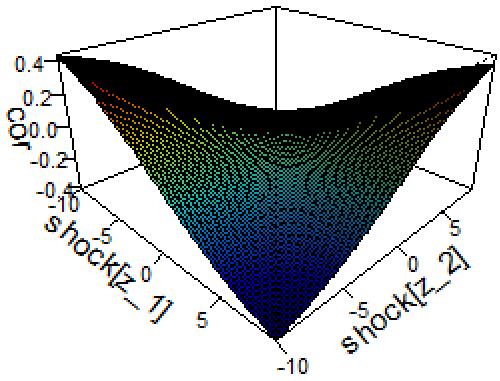
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Health Care, Oil and Gold-DCC

i) Oil

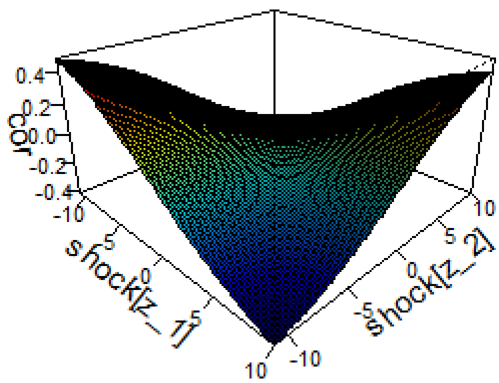


ii) Gold

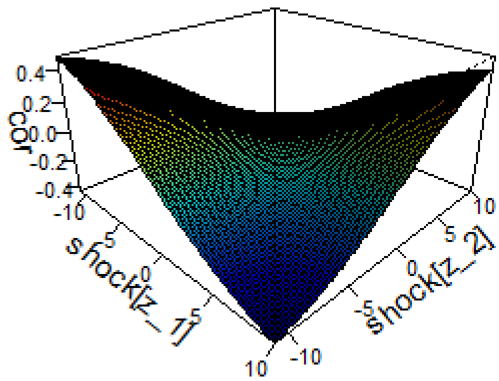


b) News Impact Correlation Surface between Health Care, Oil and Gold-ADCC

i) Oil

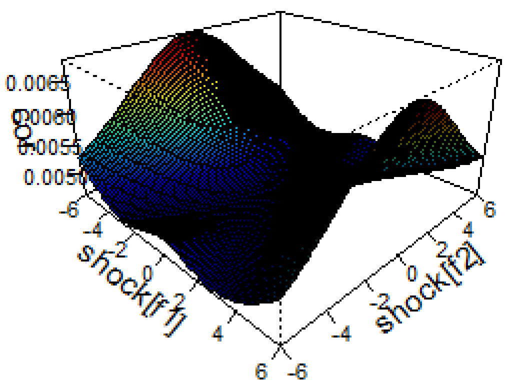


ii) Gold

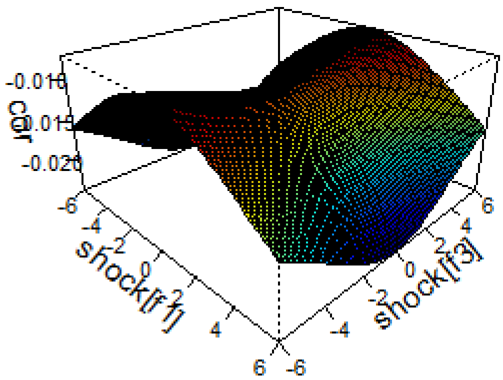


c) News Impact Correlation Surface between Health Care, Oil and Gold-GO-GARCH

i) Oil



ii) Gold



Figures 4.14a, b, c. News impact surface correlations between Health Care sector index, oil and gold assets

4.3.5.3 Optimal Hedging Strategy in Health Care Sector Index with Oil and Gold Assets

Table 4.21 reports the summary statistics of time varying hedge ratios for health care sector index/oil and gold pairs. The average value of hedge ratio computed from DCC model is 0.07 cents indicating that one dollar long position can be hedged in health care sector stocks with 0.07 cents of a short position in the gold market. Similarly, the ADCC and GO-GARCH produce the hedge ratios as 0.58 cents and 0.41 cents, respectively. For health care sector index/gold pair, the hedge ratios are negative as computed from DCC and GO-GARCH models. The negative values indicate that investors should take either a short position or a long position in the gold market. By contrast, ADCC model provides positive value of hedge ratio for heath care sector index/gold pair.

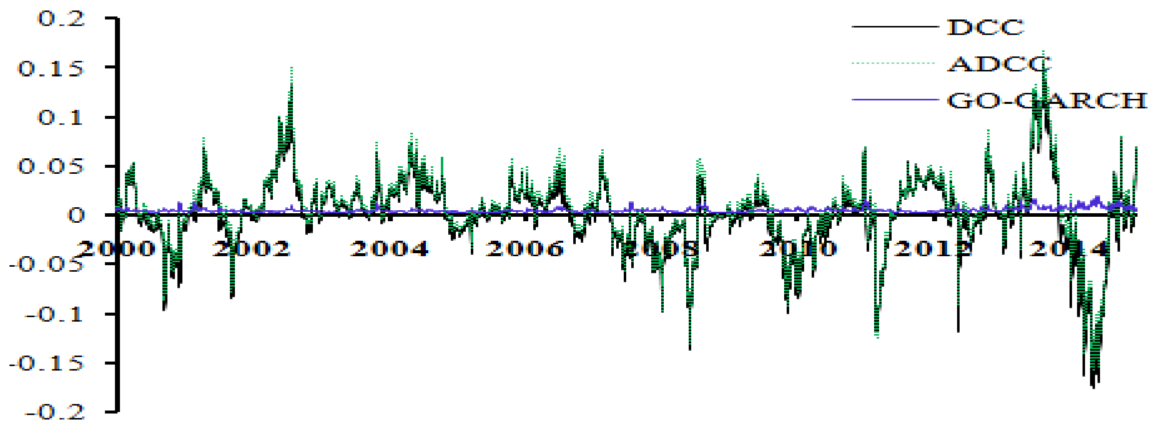
Table 4.21 Hedge Ratio Summary Statistics for Health Care Sector

	Mean	Minimum	Maximum
Health Care / Oil			
DCC	0.00069	-0.17675	0.15669
ADCC	0.00579	-0.15789	0.16783
GO-GARCH	0.00410	0.00170	0.01999
Health Care / Gold			
DCC	-0.00732	-0.33040	0.39484
ADCC	0.00627	-0.31940	0.48715
GO-GARCH	-0.02199	-0.49940	-0.00082

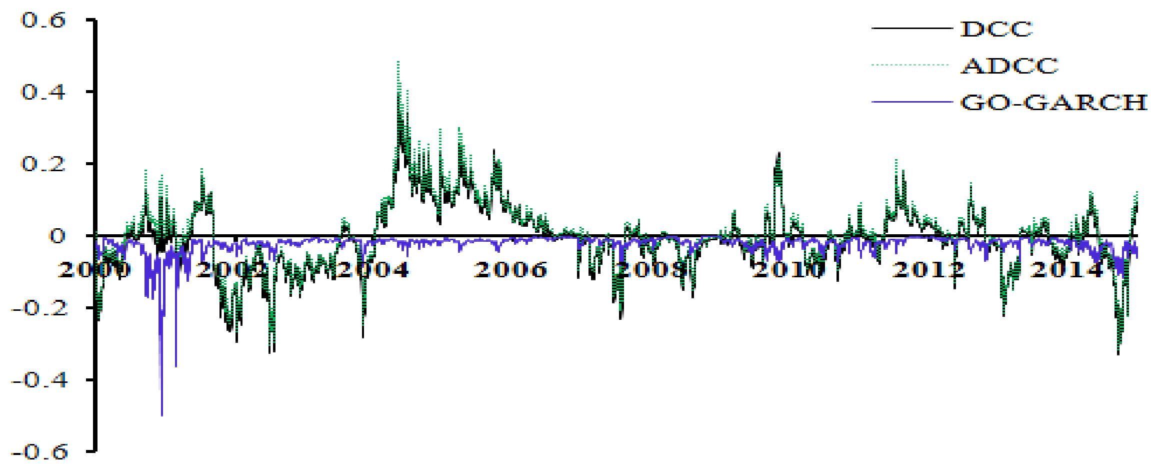
Notes: The table reports the hedge ratios for health care sector index and oil/gold pairs using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stocks is represented by the health care sector index.

Figures 4.15a, b, report the optimal hedge ratios trend among health care sector index, oil and gold pairs. In general, the hedge ratios are time varying estimated through three models; DCC, ADCC and GO-GARCH models. The hedge ratios produced from GO-GARCH model are more stable than the DCC and ADCC optimal hedge ratios. On average, DCC model produce a same pattern in hedge ratio as ADCC dynamic model. The hedge ratios between health care sector index and oil/gold pairs fluctuate between positive and negative values which indicate that, investors should rebalance the hedge ratios in planning their hedging strategies.

a) Optimal Hedge Ratio: Health Care Sector and Oil



b) Optimal Hedge Ratio: Health Care Sector and Gold



Figures 4.15a, b. Dynamic Hedge Ratios among Health Care sector index, Oil and Gold pairs

4.3.5.4 Portfolio Implication of oil and gold assets with Health Care Sector Index

Table 4.22 presents the statistics of optimal investment weights of oil and gold assets in Health Care sector index and oil/gold pairs. The average portfolio weights obtained from DCC model appear 0.1130 for health care sector index/oil portfolio. This implies that that for a 1 dollar portfolio, on average 88.70 cents should be invested in health care sector stocks and remaining, 11.30 cents should be invested in oil. The ADCC model indicates that 88.76 cents should be invested in health care sector stocks and 11.24 cents should be invested in oil market. Further, GO-GARCH model results slightly differ from those of ADCC model.

For health care sector index and gold portfolio, the investors can allocate the gold asset 2.97 cents, remainder 97.10 cents should be invested in health care sector stocks. The ADCC and GO-GARCH models produce similar investment weights but minimum and maximum values are different. These results show the importance of commodities, illustrating that adding commodities into stock portfolio decrease the portfolio risk.

Table 4.22 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Health Care / Oil				
DCC	0.11300	0.02021	1.07600	0.11480
ADCC	0.11240	0.01989	0.95900	0.11310
GO-GARCH	0.11220	0.01837	1.02400	0.11090
Health Care / Gold				
DCC	0.02898	0.00562	0.18090	0.02403
ADCC	0.02769	0.00498	0.17550	0.02343
GO-GARCH	0.02757	0.00584	0.16460	0.02194

Notes: The table reports the average optimal weight of oil and gold for health care sector index oil and gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the health care sector index.

4.3.6 Industrial Sector

The results obtained from M-GARCH specifications are shown in Table 4.23. The coefficients of conditional mean (μ) estimated in mean equation are positive and statistically significant for Industrial sector index. The autoregressive terms are statistically significant and positive for DCC and ADCC models. Further, the estimated parameters α and β are used to provide the evidence of persistence in returns in short-run and long-run, respectively. For volatility, the estimated coefficients for own conditional ARCH effect are statistically significant indicating the evidence of short-term persistence of conditional volatility. For variance equation, own GARCH effects (β) are statistically significant providing the evidence of long-term persistence behavior in variances. The estimated coefficients on own volatility long-term GARCH persistence are greater than own volatility short-term ARCH persistence.

The asymmetric effects (γ) in ADCC model is used to capture the asymmetric features of financial assets that an unexpected drop in asset returns tends to increase variances more than an unexpected increase of equal size. Hence, the estimated coefficient (γ) is positive for industrial sector index, providing the evidence that bad news (negative innovations in returns) tend to increase the future conditional volatility (variance) as compared to goods news (positive innovations in returns) of the same size. These results suggest that volatility models used in this thesis are suitable and flexible to accommodate stylized effects including the volatility clustering and asymmetric long range volatility. These results also suggest that portfolio managers and investors implement active investment strategies on the basis of long-run persistence and latest volatility shocks. Moreover, the estimated coefficient values of shape parameter (λ) obtained from DCC and ADCC models are over 4 for industrial sector index. While, the estimated values of shape parameters are 6 and 4 for oil and gold assets[9], respectively. Mainik *et al.* (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by abnormal returns originate from assets returns with heavy-tail distribution. If this is so, then the lowest value of alternative asset i.e. gold provides heavier tails which shows that gold exhibits better diversification benefits in portfolio. The estimated coefficients on θ_1 and θ_2 are positive for Industrial sector index but only the estimated coefficients of θ_2 is statistically significant at 1% level. The estimated sum values of these parameters are less than one which suggests that dynamic conditional correlations are mean reverting. In case of GO-GARCH model, volatility persistence findings are in line with the results of other two models. Finally, the DCC model is fitted on the basis of selection criterion as compared to ADCC and GO-GARCH models.

Table 4.23 DCC, ADCC and GO-GARCH Parameters Estimates for Industrial Sector Index

	DCC			**ADCC**		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.1196***	0.0165	7.2677	0.1051***	0.0167	6.2937
a	0.0466***	0.0171	2.7198	0.0569***	0.0175	3.2593
ω	0.0727***	0.0162	4.4942	0.0902***	0.0194	4.6523
α	0.1812***	0.0209	8.6828	0.1127***	0.0173	6.5019
β	0.8065***	0.0208	38.8190	0.7886***	0.0235	33.5546
λ	4.5254***	0.3248	13.9347	4.5879***	0.3323	13.8057
γ				0.1487***	0.0360	4.1353
θ1	0.9378	0.0073	1.2812	0.0090	0.0082	1.0971
θ2	0.9378***	0.0826	11.3498	0.9364***	0.1007	9.3006
θ3				0.0012	0.0044	0.2655
λ	6.0456***	0.2738	22.0763	6.2012***	0.2883	21.5081
Akaike	10.349			10.335		
Bayes	10.387			10.380		
Shibata	10.349			10.335		

[9] The values of oil and gold assets are all similar for all sectors as reported in Basic Materials sector results.

H-Q	10.363	10.351
L- L	-20224	-20192

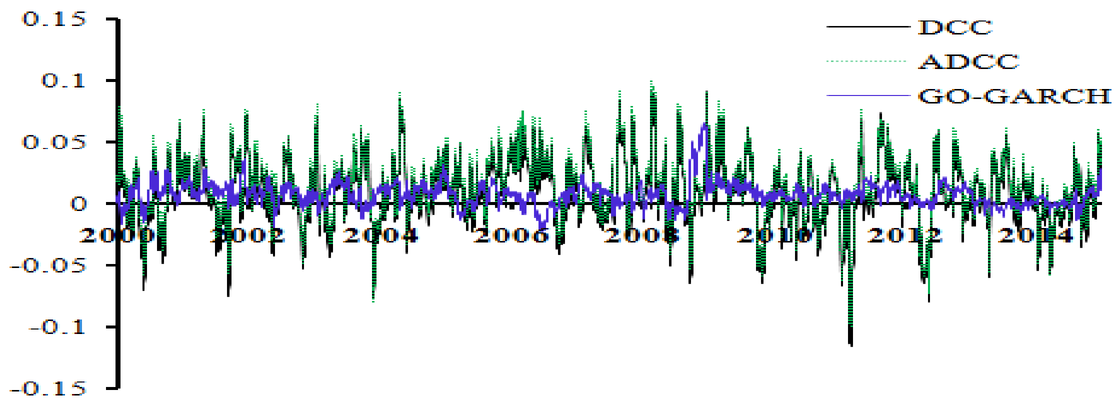
GO-GARCH Parameters Estimates	Factor
ω	0.0348
α	0.1647
β	0.8109
Skew	-0.1284
λ	1.0810
L- L	-20101.9
No. of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***, **,*).

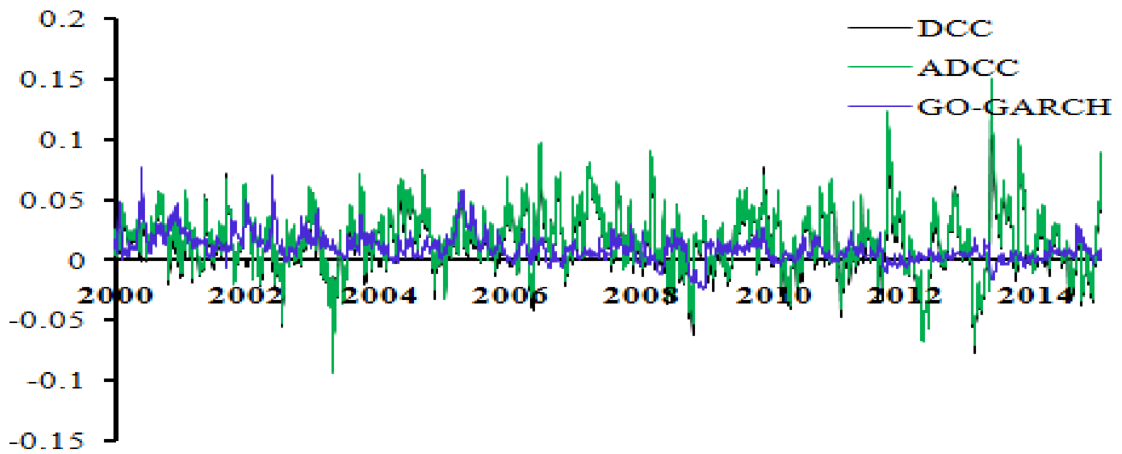
4.3.6.1 Time Varying Conditional Correlations

The dynamic conditional correlations are presented in figures 4.16a, b, estimated through different multivariate GARCH models. The estimated conditional correlations provide a highly volatile trend over the sample period especially in the crisis time over 2007-2009. It is interesting to note that all models show a different pattern in correlations over the sample period. Consequently, correlations estimated through DCC model are highly correlated with ADCC model's correlations. Whereas, conditional correlations produced from GO-GARCH model are uncorrelated with the DCC and ADCC model's correlations which shows a least volatile trend for whole sample period. There is no clear constant decrease and increase in correlations for DCC and ADCC models.

a) Dynamic Conditional Correlations: Industrial Sector Index and Oil



b) Dynamic Conditional Correlations: Industrial Sector Index and Gold



Figures 4.16a, b. Time varying correlations among Industrial sector index, Oil and Gold pairs

4.3.6.2 Correlation between Correlations

The correlations produced from all three models are shown in table 4.24. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.17a, b and c. In figures 4.17a, b, along z_1 axis (industrial sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.17c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

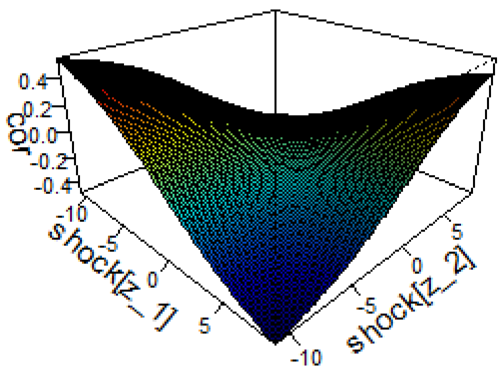
Table 4.24. Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Industrial Sector / Oil	Industrial Sector / Gold
DCC / ADCC	0.9951	0.9953
DCC / GO-GARCH	0.0510	0.0317
ADCC /GO-GARCH	0.0430	0.0237

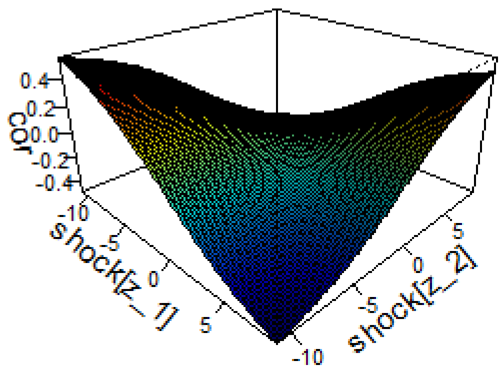
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Industrials, Oil and Gold-DCC

i). Oil

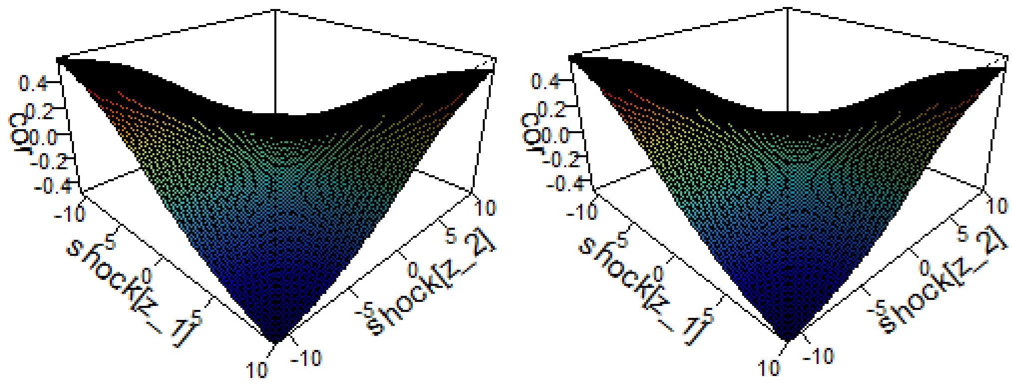


ii).Gold



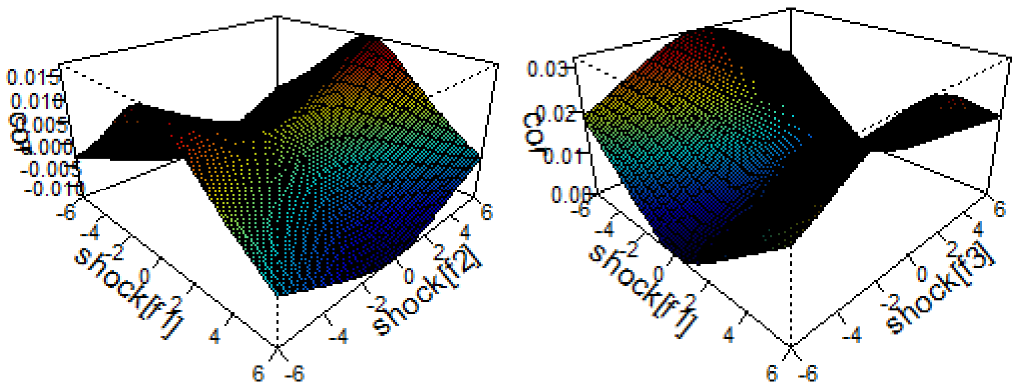
b) News Impact Correlation Surface between Industrials, Oil and Gold-ADCC

i). Oil ii).Gold



c) News Impact Correlation Surface between Industrials, Oil and Gold-GO-GARCH

i). Oil ii).Gold



Figures 4.17a, b, c. News impact surface correlations between Industrials sector index, oil and gold assets

4.3.6.3 Optimal Hedging Strategy in Industrials Sector Index with Oil and Gold Assets

The optimal hedge ratios of industrial sector index and oil/gold pairs are presented in Table 4.25. The average value of hedge ratio is 0.00644 for industrial sector index/oil pair which is computed form DCC model. This shows that one dollar long position in industrial sector stocks can be hedged with 0.64 cents of a short position in oil market. The values of hedge ratios 0.00985 and 0.00279 respectively, indicating that investors can hedged a one dollar long position in industrial sector stocks with 0.99 cents and 0.28 cents of a short position in oil market. While, one dollar long position in an industrial sector stocks can be hedge through a short position in gold market with 2.05 cents. At last, ADCC model produces mainly different results when compared with DCC and GO-GARCH models.

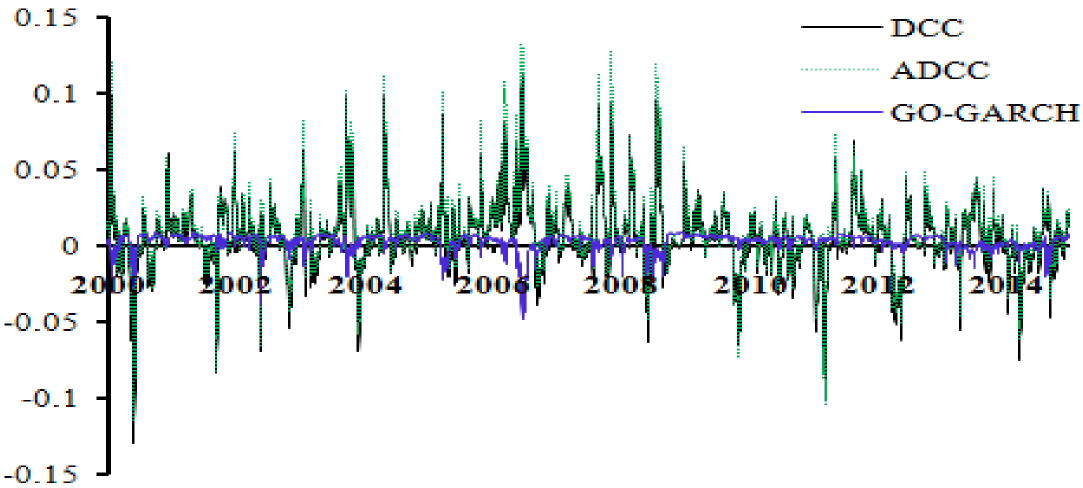
Table 4.25 Hedge Ratio Summary Statistics For Industrial Sector

	Mean	Minimum	Maximum
Industrials / Oil			
DCC	0.00644	-0.12980	0.11283
ADCC	0.00985	-0.11521	0.13350
GO-GARCH	0.00279	-0.04881	0.00906
Industrials / Gold			
DCC	0.02048	-0.16486	0.25470
ADCC	0.02524	-0.19908	0.32720
GO-GARCH	0.02084	-0.00662	0.51840

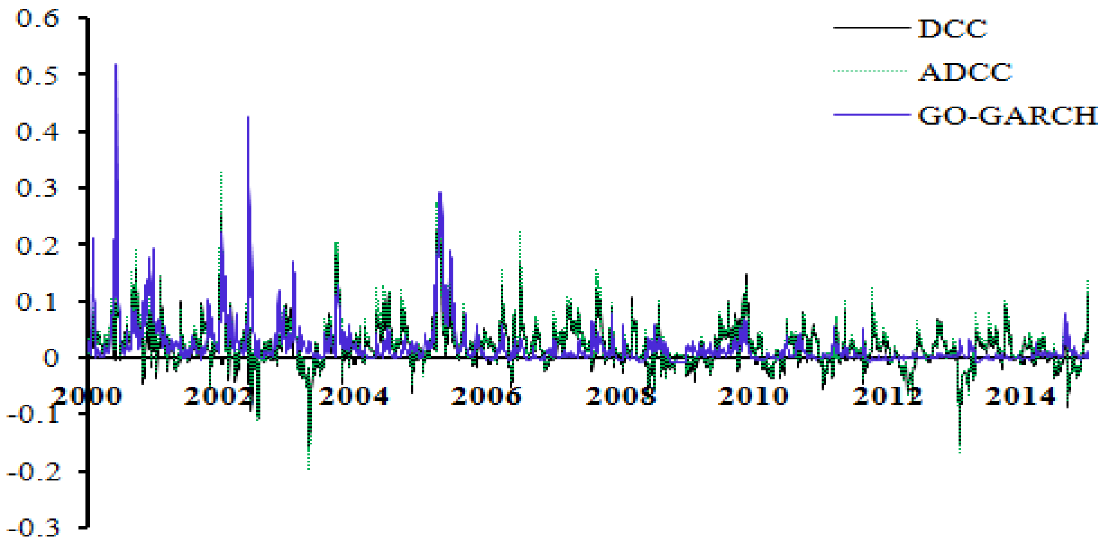
Notes: The table reports the hedge ratios for Industrial sector index and oil/ gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented gold bullions price index, while the investment in stock is represented by the industrial sector index.

The general trend in hedge ratios are presented in figures 4.18a, b. All hedge ratios are developed through multivariate GARCH specifications providing that the optimal hedge ratios are dynamic in nature throughout the study period. On average, a positive trend in hedge ratios is estimated through DCC and ADCC models during all periods. While, GO-GARCH model estimate an inverse association in hedge ratios for industrial sector index/oil pair, a positive association is observed in dynamic hedge ratios of industrial sector index and gold pair.

a) Optimal Hedge Ratio: Industrial Sector Index and Oil



b) Optimal Hedge Ratio: Industrial Sector Index and Gold



Figures 4.18a, b. Dynamic Hedge Ratios among Industrial sector index, Oil and Gold pairs

4.3.6.4 Portfolio Implication of oil and gold assets with Industrial Sector Index

Table 4.26 presents the optimal investment weights for portfolios comprising industrial sector index and oil/gold pairs. The DCC model produces the average weight for industrial sector index/oil portfolio as 0.11220 on average, indicating that for a one dollar portfolio, 88.78 cents should be invested in industrial sector stocks and remaining, 11.22 cents should be invested in oil. The ADCC model indicates that 88.82 cents should be invested in industrial sector stocks and 11.18 cents should be invested in oil market.

Further, the GO-GARCH model provides a slightly different result in comparison with ADCC model results. For industrial sector index/gold portfolio, the optimal allocation of gold should be 2.82 cents and remainder 97.18 cents should be invested in industrial sector stocks. The ADCC produces average weight of the industrial sector stock/gold portfolio as 0.02714, which shows that for a one dollar portfolio, investors can invest 97.29 cents in industrial sector stocks and 2.71 cents can invest in gold. While, GO-GARCH model indicates that 97.32 cents should be invested in industrial sector stocks and 2.68 cents should be invested in gold asset.

Table 4.26 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Industrials / Oil				
DCC	0.11220	0.01876	1.04610	0.11290
ADCC	0.11180	0.01846	0.94340	0.11140
GO-GARCH	0.11190	0.01882	1.00940	0.10930
Industrials / Gold				
DCC	0.02818	0.00503	0.17710	0.02353
ADCC	0.02714	0.00434	0.17630	0.02304
GO-GARCH	0.02675	0.00431	0.16740	0.02225

Notes: The table reports the average optimal weight of oil and gold for industrial sector index oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the industrial sector index.

4.3.7 Oil and Gas Sector

The results for oil and gas sector produced from M-GARCH specifications are shown in Table 4.27. The estimated coefficients of conditional mean (μ) in mean equation are positive and significant. The estimated coefficient for autoregressive term is positively significant specifying that realizations in past returns of stocks in this sector help to predict the returns in future. In variance equation, own conditional ARCH effect (α) is used to measure the short-run persistence. The estimated coefficient for own conditional ARCH effect is statistically significant indicating the evidence of short-term persistence of conditional volatility. For variance equation, own GARCH effects (β), is clearly important to explain long range volatility persistence. The estimated coefficients of own GARCH effect (β) are statistically significant which provides the evidence of long term persistence behavior in variances. The estimated value of α parameter is less than the estimated values of β parameter indicating that own volatility long-term GARCH persistence is greater than own volatility short-term ARCH persistence. The small size of ARCH effect indicates that conditional volatility does not change quickly due to the returns' innovations. In case of large size of GARCH effect, the estimated conditional volatility series tend to fluctuate rapidly over time relating to substantial effects of past volatility. These results indicate that investors and portfolio managers implement active investment strategies based on current market shocks and long run persistence in volatility while seeking profit from oil and gas sector stocks. The degree of freedom is denoted by the shape parameter (λ) which indicates that the estimated value is 4 for oil and gas sector index. In comparison with gold[10], oil has highest estimated values of shape parameters indicating that oil asset with lighter tail lack a diversification benefit in portfolio. Nonetheless, gold with heavier tails provide better diversification benefit in portfolio. The estimated coefficient for the asymmetric effects (γ) is positive providing the evidence that negative innovations in returns lead to increase the future volatility (variance) more than positive innovations in returns of the same size. The results push the investors to search the hedge and safe haven instruments in order to their investments at the time crisis in financial markets. The parameters θ_1 and θ_2 are non-negative and also associated with exponential smoothing process; used to construct the dynamic conditional correlations. The dynamic conditional correlations for Oil and Gas industrial sector, oil and gold pairs are not constant as long as the $\theta_1 + \theta_2 < 1$. The results for volatility persistence i.e., a long and short term volatility persistence estimated through GO-GARCH model are similar to DCC and ADCC models. At last, the DCC model outperforms the other models on the basis of all models selection criterion.

Table 4.27 DCC, ADCC and GO-GARCH Parameters Estimates for Oil & Gas Sector Index

	DCC			ADCC		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.0692***	0.0180	3.8378	0.0585***	0.0184	3.1726
a	0.0170	0.0180	0.9461	0.0207	0.0180	1.1493
ω	0.0873***	0.0271	3.2187	0.0987***	0.0315	3.1374
α	0.1838***	0.0261	7.0383	0.1521***	0.0224	6.7911
β	0.8152***	0.0271	30.0971	0.8030***	0.0308	26.0941
λ	4.2188***	0.2755	15.3154	4.2147***	0.2781	15.1536
γ				0.0878***	0.0348	2.5256
θ_1	0.0062*	0.0035	1.7799	0.0054*	0.0032	1.6798
θ_2	0.9666***	0.0257	37.6267	0.9669***	0.0260	37.2182

[10] The values of oil and gold assets are all similar for all sectors as reported in Basic Materials sector results

θ_3				0.0020	0.0029	0.6982
λ	5.9055***	0.2603	22.6914	6.0394***	0.2744	22.0092
Akaike	10.707			10.698		
Bayes	10.746			10.743		
Shibata	10.707			10.698		
H-Q	10.721			10.714		
L- L	-20925			-20904		

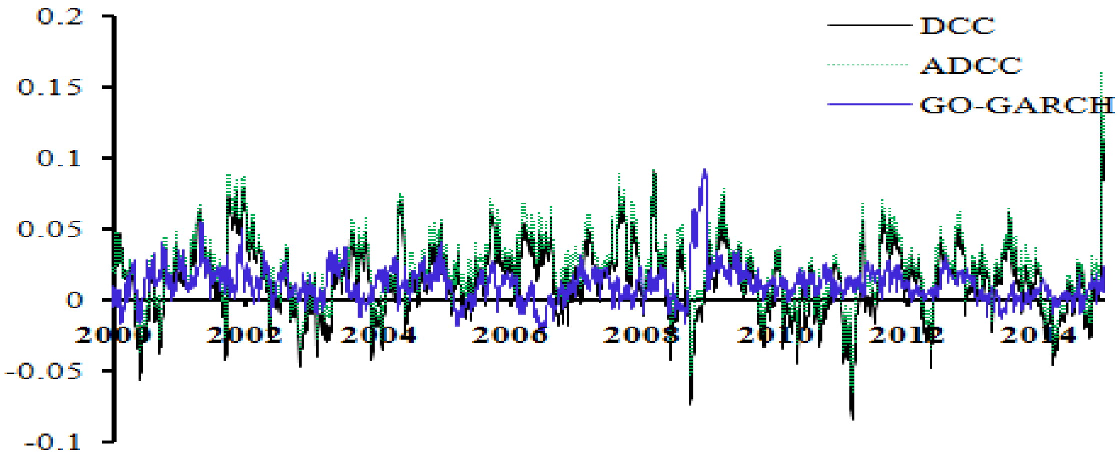
GO-GARCH Parameters	**Factor**
ω	0.0305
α	0.1809
β	0.8070
Skew	0.0063
λ	0.9033
L- L	-20802.7
No.of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%, 5% and 10% is shown by an asterisk (***,**,*).

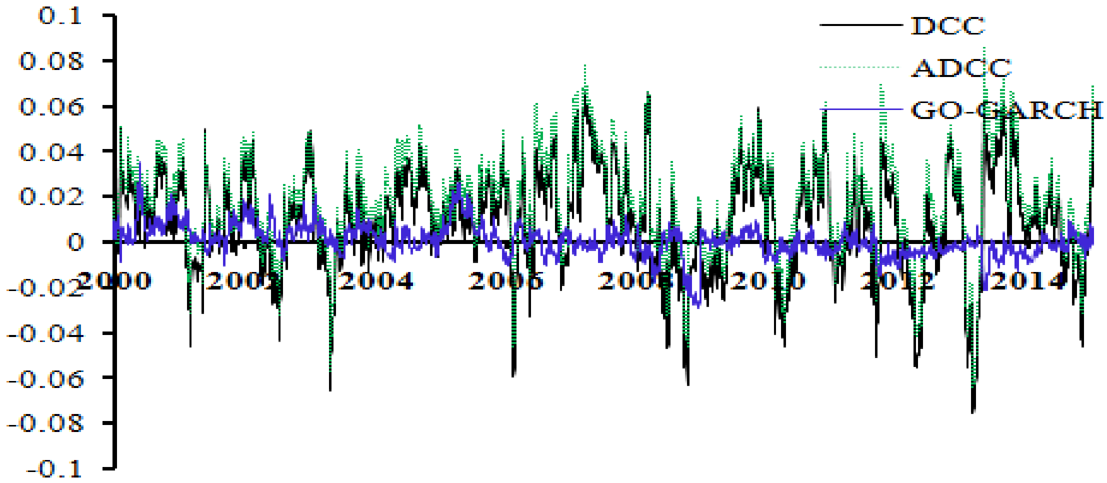
4.3.7.1 Time Varying Conditional Correlations

The dynamic conditional correlations for oil and gas sector index and oil/gold pairs are plotted in figures 4.19a, b. The three different multivariate GARCH models are applied for constructing the time-varying conditional correlations. The conditional correlations have changed significantly during the entire study time. This confirms the conventional understanding of market participants that stocks, oil and gold assets are driven by common macroeconomic factor e.g. anticipated inflation. Specifically, the correlations show an upward and downward trend at the time economic instability 2007-2009. A strong negative association between oil and gas sector index and gold pair confirms a status of gold as safe haven asset in this crisis time. The dynamic conditional correlations estimated through DCC model are highly correlated with ADCC model's correlations. Whereas, conditional correlations produced from GO-GARCH model are uncorrelated with DCC and ADCC model's correlations.

a) Dynamic Conditional Correlations: Oil and Gas Sector Index and Oil



b) Dynamic Conditional Correlations: Oil & Gas Sector Index and Gold



Figures 4.19a, b. Time varying correlations among Oil and Gas sector index, Oil and Gold pairs

4.3.7.2 Correlation between Correlations

The correlations produced from all three models are provided in table 4.28. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.20a, b and c. In figures 4.20a, b, along z_1 axis (oil & gas sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.20c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

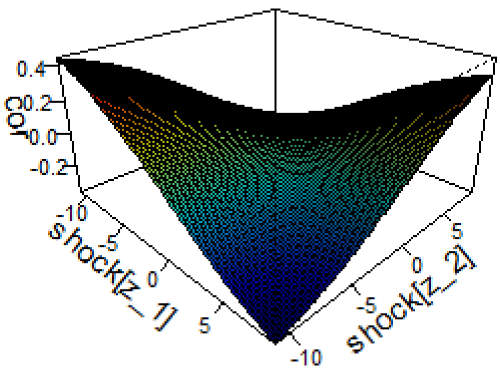
Table 4.28 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Oil and Gas Sector / Oil	Oil and Gas Sector / Gold
DCC / ADCC	0.9889	0.9880
DCC / GO-GARCH	0.0350	0.0778
ADCC / GO-GARCH	0.0345	0.0577

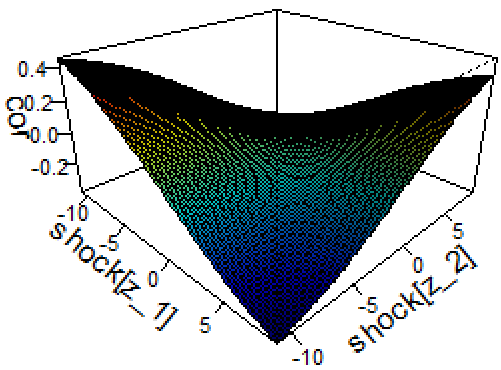
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Oil & Gas Sector Index, Oil and Gold-DCC

i) Oil

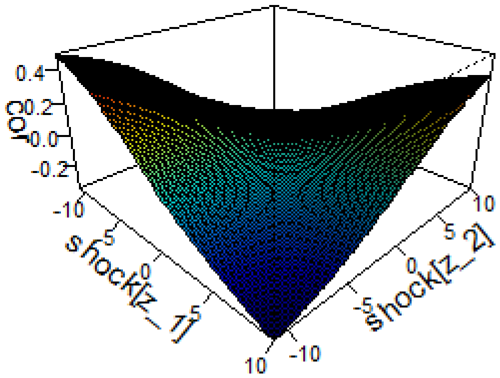


ii) Gold

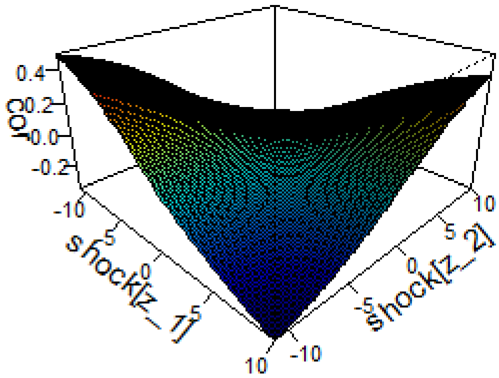


b) News Impact Correlation Surface between Oil & Gas Sector Index, Oil and Gold-ADCC

i) Oil

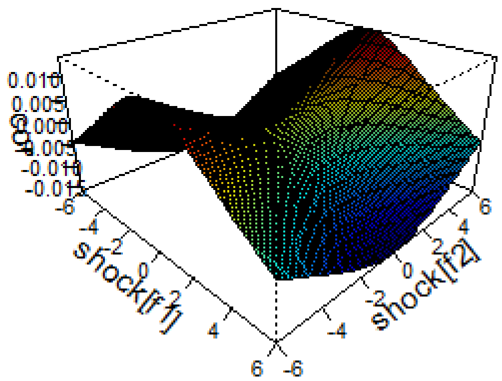


ii) Gold

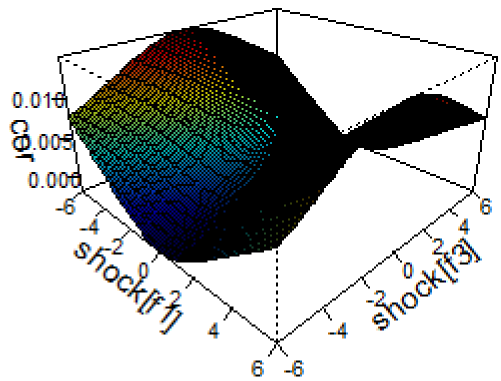


c) News Impact Correlation Surface between Oil & Gas Sector Index, Oil and Gold-GO-GARCH

i) Oil



ii) Gold



Figures 4.20a, b, c. News impact surface correlations between Oil & Gas sector index, oil and gold assets

4.3.7.3 Optimal Hedging Strategy in Oil and Gas Sector Index with Oil and Gold Assets

For DCC model, the average value of hedge ratio i.e. 0.01120 between oil and gas sector index and oil pair indicate that one dollar long position in oil and gas sector stocks can be hedged with a short position 1.12 cents in oil market (Table 4.29). While, ADCC model suggests that one dollar long position in oil and gas sector stocks can be hedged for 1.79 cents with a short position in oil market. For oil and gas sector index and gold pair, hedge ratios are different as compared to oil commodity. The mean value computed from DCC and ADC models of the hedge ratio between oil and gas sector index and gold pair is 0.01592 and 0.03034, respectively, indicating that one dollar long position in oil and gas sector stocks can he hedged with 1.59 cents and 3.03 cents by taking short position in gold market. Moreover, GO-GARCH model provide least hedge ratios in both cases on comparison.

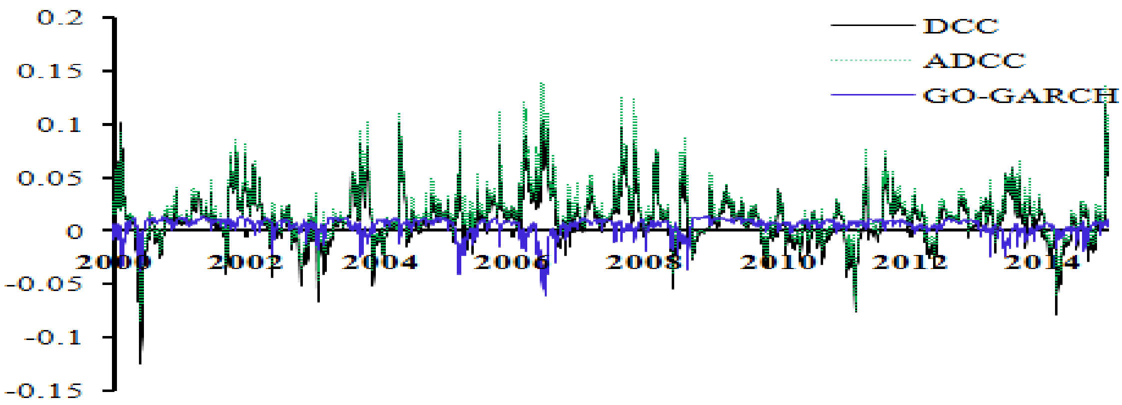
Table 4.29 Hedge Ratio Summary Statistics for Oil and Gas Sector

	Mean	Minimum	Maximum
Oil & Gas / Oil			
DCC	0.01120	-0.12438	0.11888
ADCC	0.01790	-0.08502	0.13851
GO-GARCH	0.00507	-0.06094	0.01407
Oil & Gas / Gold			
DCC	0.01592	-0.13984	0.19020
ADCC	0.03034	-0.13328	0.27140
GO-GARCH	0.00658	-0.00893	0.29590

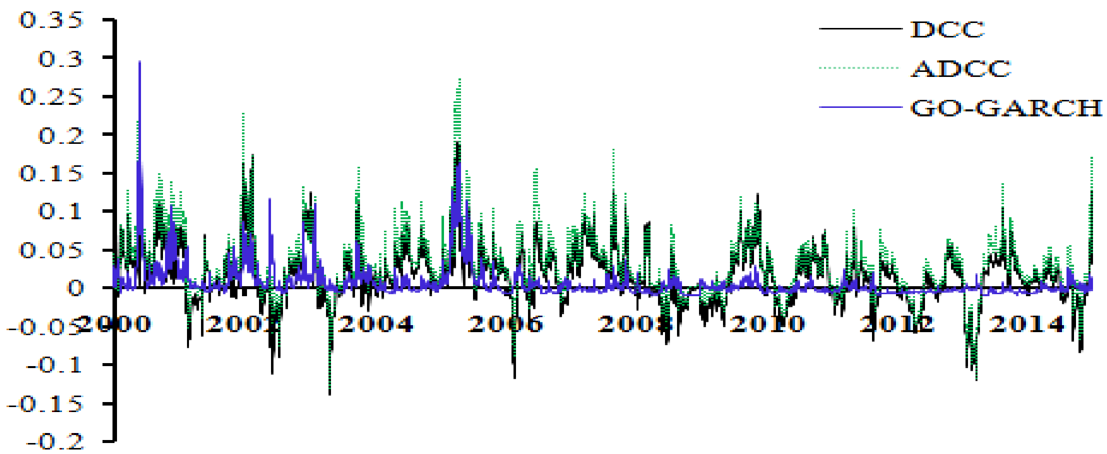
Notes: The table reports the hedge ratios for oil and gas sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the oil and gas sector index.

Further, the hedge ratios developed through multivariate GARCH models are dynamic in nature as shown in figure 4.21a, b. Generally, positive trend in hedge ratios are estimated through DCC and ADCC models during all periods. It is also viewed that hedge ratios vary from their mean values among oil and gas sector index and oil/gold pairs across the sample period. Specifically, a positive trend in hedge ratios is prominent between oil and gas sector index/oil pair during the episode of market downturns 2007-2009. It means that investors take long position in sector stocks and short position in oil asset. However, hedge ratios fluctuate between positive and negative values between oil and gas sector index/gold pair which indicates that, investors should rebalance the hedge position in planning the strategy to hedge across the study period.

a) Optimal Hedge Ratio: Oil and Gas Sector Index / Oil



b) Optimal Hedge Ratio: Oil and Gas Sector Index / Gold



Figures 4.21a, b. Dynamic Hedge Ratios among Oil and Gas sector index, Oil/Gold pairs

4.3.7.4 Portfolio Implication of Oil and Gold assets with Oil and Gas Sector Index

The summary statistics for portfolio weights computed from DCC, ADCC and GO-GARCH models are reported in table 4.30. The average weight for the oil and gas sector stocks/oil portfolio is 0.11160, indicating that for one dollar portfolio, 11.16 cents should be invested in oil and gas sector stocks and 88.84 cents should be invested in oil commodity as estimated through DCC model and GO-GARCH models. While, ADCC model suggests that 11.09 cents should be invested in oil and gas sector stocks and remaining 88.91 should be invested in oil market. Further, portfolio weights oil and gas sector index/gold pair provide different results. The ADCC and GO-GARCH models provide parallel findings with each other for one dollar portfolio. While, DCC model indicates that investors should invest 2.84 cents in oil and gas sector stocks and 97.16 cents gold market.

Table 4.30 Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Oil and Gas / Oil				
DCC	0.11160	0.01883	1.04540	0.11270
ADCC	0.11090	0.01848	0.93590	0.11090
GO-GARCH	0.11160	0.01879	1.00550	0.10870
Oil and Gas / Gold				
DCC	0.02843	0.00520	0.17960	0.02388
ADCC	0.02710	0.00435	0.17680	0.02317
GO-GARCH	0.02708	0.00486	0.16770	0.02229

Notes: The table reports the average optimal weight of oil and gold for oil and gas sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the oil and gas sector index.

4.3.8 Telecommunication Sector

The empirical results as produced from M-GARCH type specifications are shown in Table 4.31. The estimated coefficient value is positive for as measured through DCC model for conditional mean (μ), but, the estimated coefficient value of conditional mean is negative as computed from ADCC model. The negative estimated coefficient of autoregressive term indicates that past realizations of stocks returns do not facilitate predicting the future stock returns; consistent with previous study of Arouri *et al.* (2011) in Europe and United States. Furthermore, own conditional ARCH effect (α) is significant which is used to measure the short-run persistence of volatility providing the evidence of short-term persistence of conditional volatility. For variance equation, the estimated values of own GARCH effect (β) are statistically significant which provides the evidence of long-term persistence behavior in variances. The estimated α value is less than the estimated coefficient value of β, indicating that long term persistence is greater than that of short-run. These results provide the evidence that investors and portfolio managers will earn high returns on investment in the short run. The shape parameter (λ) shows the degree of freedom which indicates that the shape of t-distribution approaches to normal as number of degree of freedom reaches to infinity. The estimated coefficient values (i.e., 4) of shape parameter (λ) are less than the value of oil asset[11]. The highest estimated values of shape parameter (i.e., 6) are found for oil asset, while, gold series report a lowest values. In literature, Mainik *et al.* (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by

[11] The values of oil and gold assets are all similar for all sectors as reported in Basic Materials sector results.

abnormal returns originate from assets returns with heavy-tail distribution. Hence, gold having heavier tail offer large portfolio benefits in comparison to oil asset which exhibits a lowest tails. Furthermore, these findings also suggest that gold with heavier tails provide better diversification benefits in mixed assets portfolio as compared to oil asset.

Moreover, the estimated coefficient value of leverage effect (γ) is positive suggesting that bad news in considered markets lead to raise the future volatility (variance) as compared to good news of the same size. The estimated coefficients on θ_1 and θ_2 are positive, but the estimated coefficient on θ_2 is statistically significant at the only 1% level. The estimated sum value of these two parameters is less than one, suggesting that dynamic conditional correlations are not constant over time. The results of volatility persistence i.e., long run persistence greater than short run persistence computed through GO-GARCH model is similar with results of DCC and ADCC models. The model selection criterion measure the relative goodness of fit which indicate that DCC-GARCH is fitted model.

Table 4.31 DCC, ADCC and GO-GARCH Parameters Estimates for Telecommunication Sector Index

	DCC			**ADCC**		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	0.0008	0.0232	0.0366	-0.0022	0.0238	-0.0940
a	0.0117	0.0176	0.6617	0.0118	0.0176	0.6681
ω	0.2075***	0.0637	3.2568	0.2129***	0.0678	3.1422
α	0.1995***	0.0280	7.1277	0.1917***	0.0271	7.0723
β	0.7995***	0.0295	27.1321	0.7963***	0.0317	25.0955
λ	3.7324***	0.2194	17.0114	3.7312***	0.2195	16.9963
γ				0.0221	0.0333	0.6634
θ1	0.0089	0.0087	1.0254	0.0085	0.0099	0.8664
θ2	0.9411***	0.0964	9.7609	0.9352***	0.1470	6.3608
θ3				0.0021	0.0081	0.2594
λ	5.6569***	0.2443	23.1548	5.7722***	0.2555	22.5892
Akaike	11.281			11.275		
Bayes	11.320			11.320		
Shibata	11.281			11.275		

H-Q	11.295	11.291
L- L	-22048	-22032

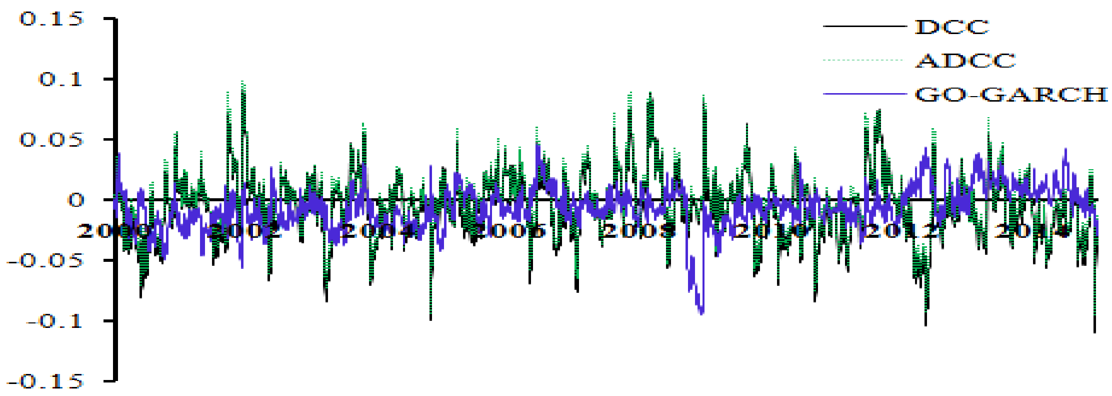
GO-GARCH Parameters	Factor
ω	0.0414
α	0.1839
β	0.8007
Skew	0.0089
λ	0.7025
L- L	-21897.3
No.of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%,5% and 10% is shown by an asterisk (***,**,*).

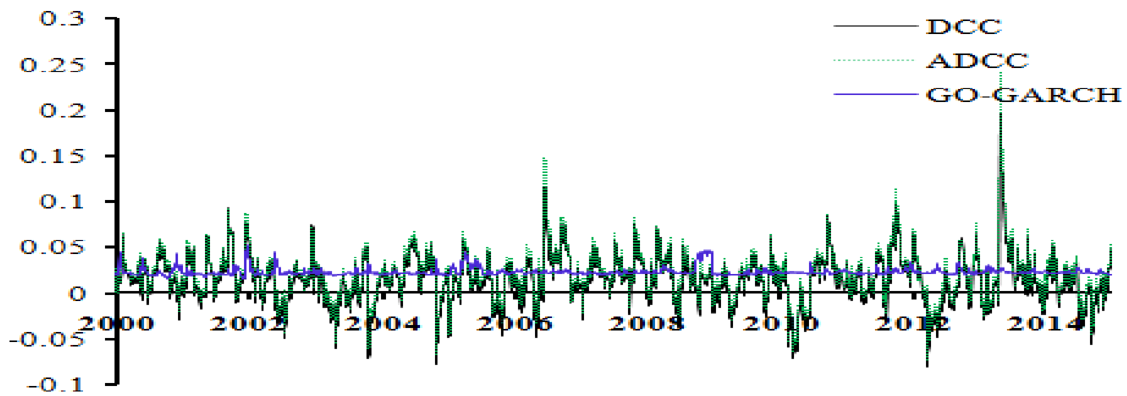
4.3.8.1 Time Varying Conditional Correlations

Figures 4.22a, b indicates conditional correlations between telecommunication sector index and oil/gold pairs as developed from DCC, ADCC and GO-GARCH models. The correlations between telecommunication sector index and oil pair, produced from DCC model, are highly correlated with ADCC model though much different from the GO-GARCH correlations. The oil assets observed positive correlations with telecommunication sector index, whereas, negative trend in conditional correlation is detected. This indicates that oil act as safe haven asset for sector stocks. For telecommunication sector index and gold pair, significant negative value (i.e.-0.07) of correlation is observed in 2012 which turned into positive value (i.e. 0.24) in 2013. However, the correlations between telecommunication sector index and gold pair provides significant variability among strong positive to weak and weak negative trend. This specifies that correlations are not stable and explains the regime specific diversification benefits of gold.

a) Dynamic Conditional Correlations: Telecommunication sector index and Oil



b) Dynamic Conditional Correlations: Telecommunication sector index and Gold



Figures 4.22a, b. Time varying correlations among Telecommunication sector index, Oil and Gold pairs

4.3.8.2 Correlation between Correlations

The correlations produced from all three models are given in table 4.32. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.23a, b and c. In figures 4.23a, b, along z_1 axis (telecommunication sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.23c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

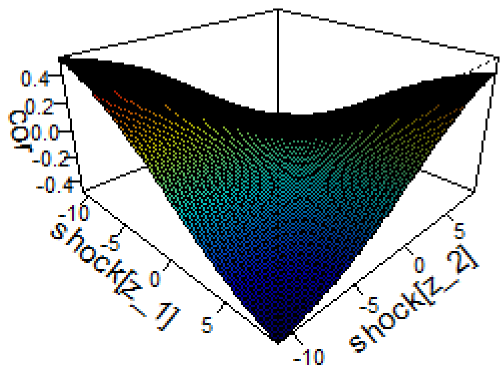
Table 4.32 Correlation between Correlations DCC, ADCC and GO-GARCH Models

	Telecommunication Sector/Oil	Telecommunication Sector/Gold
DCC / ADCC	0.9939	0.9926
DCC / GO-GARCH	0.0117	0.0345
ADCC / GO-GARCH	0.0238	0.0413

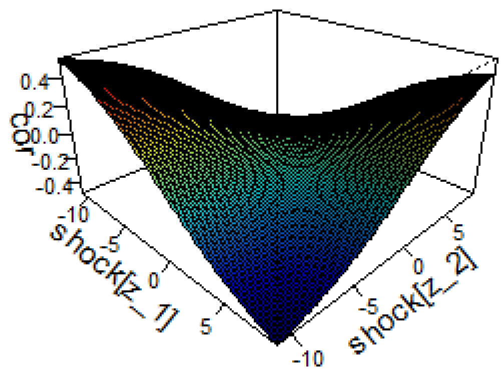
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Telecommunication Sector Index, Oil and Gold-DCC

i) Oil

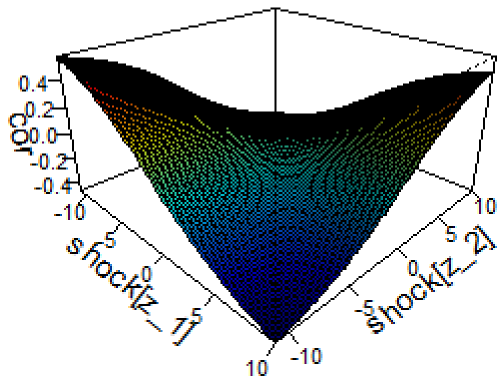


ii) Gold

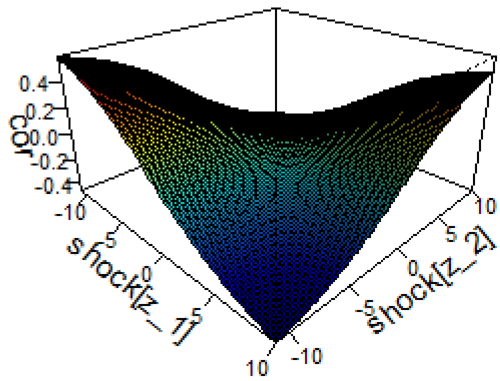


b) News Impact Correlation Surface between Telecommunication Sector Index, Oil and Gold-ADCC

i) Oil

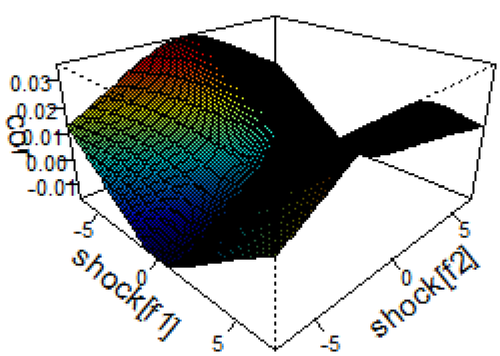


ii) Gold

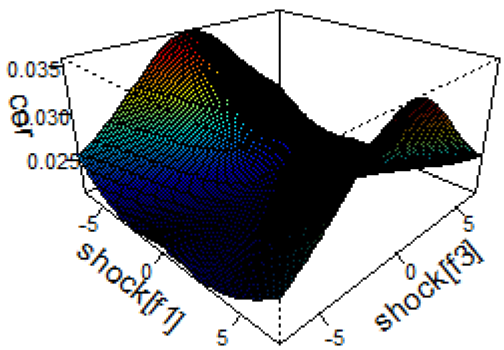


c) News Impact Correlation Surface between Telecommunication Sector Index, Oil and Gold-GO-GARCH

i) Oil



ii) Gold



Figures 4.23a, b, c. News impact surface correlations between Telecom--munication sector index, Oil and Gold pairs

4.3.8.3 Optimal Hedging Strategy in Telecommunication Sector Index with Oil and Gold Assets

The estimated hedge ratios summary for telecommunication sector stocks and oil/gold are presented in table 4.33. The DCC and ADCC models produce the mean values of hedge ratios that are negative for telecommunication sector index /oil pairs.

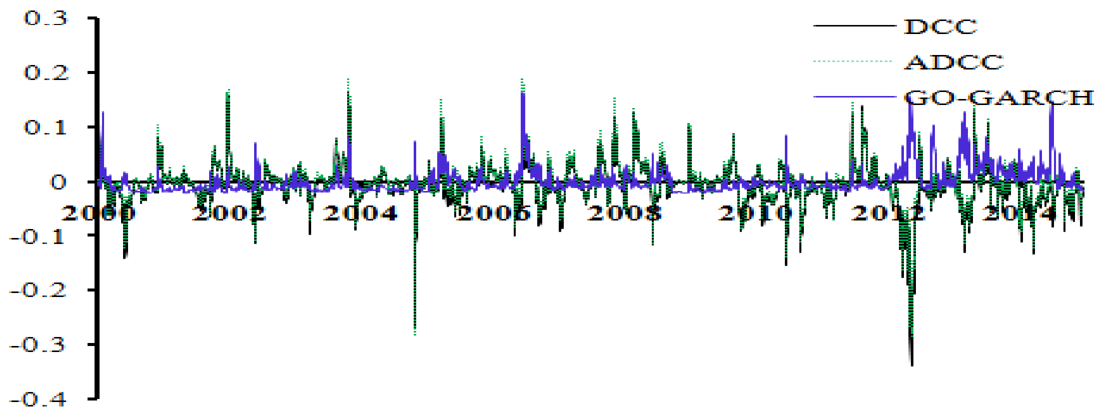
The negative mean values of hedge ratios indicate that investors should take a short position in first asset and a long position in second asset. The GO-GARCH model provides the hedge ratio value on average i.e. 0.0006, which shows that one dollar long position in telecommunication sector stocks can be hedged by 0.06 cents short position in oil market. Note that, the considerable variability of the hedge ratios appears through the minimum and maximum values. The minimum negative values for hedge indicate that a short position should be taken in first asset and a long position should be taken in second asset. In case of telecommunication sector index/gold hedge ratios, one dollar long position in telecommunication sector stocks can be hedged by 3.11 cents in gold through DCC model. While, ADCC and GO-GARCH models indicate that for one dollar long position in telecommunication sector stocks, investors can be hedged 4.31 cents and 5.24 cents in gold asset, respectively. Likewise, considerable variability in telecommunication sector index/oil hedge ratios is observed over the study period (figures 4.24a, b). By contrast, telecommunication sector index/gold hedge ratios are less variant over the sample period. There is no clear constant decrease and increase in correlations produced from all models.

Table 4.33. Hedge Ratio (long / short) Summary For Telecommunication Sector Index

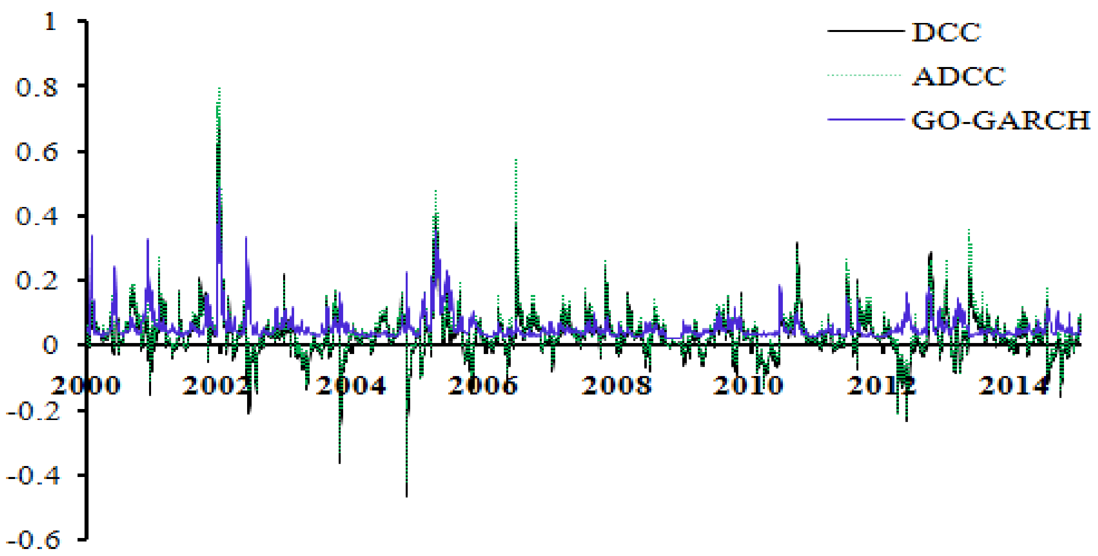
	Mean	Minimum	Maximum
Telecommunication / Oil			
DCC	-0.0074	-0.33808	0.1659
ADCC	-0.0028	-0.28483	0.19
GO-GARCH	0.00056	-0.02034	0.1639
Telecommunication / Gold			
DCC	0.0311	-0.46808	0.6762
ADCC	0.04308	-0.42653	0.7997
GO-GARCH	0.05244	0.01996	0.4887

Notes: The table reports the hedge ratios for telecommunication sector index and oil/gold portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the telecommunication sector index.

a) Optimal Hedge Ratio: Telecommunication sector index and Oil



b) Optimal Hedge Ratio: Telecommunication sector index and Gold



Figures 4.24a, b. Dynamic Hedge Ratios among Telecommunication sector index, Oil and Gold pairs

4.3.8.4 Portfolio Implication of Oil and Gold assets with Telecommu-nication Sector Index

The optimal investment weights for portfolios comprising telecommunication sector index and oil/gold are presented in table 4.34. The optimal allocation of oil in a telecommunication sector stocks-oil portfolio should be 11.36 cents and remaining 88.64 cents should be invested in telecommunication sector stocks as computed through DCC model. For ADCC model, the optimal portfolio weight is 0.1132 on average, indicating that for a one dollar portfolio, 88.68 cents should be invested in telecommunication sector stocks and 11.32 cents should be invested in oil market. While, portfolio weight for investment in oil and stocks are different as computed through GO-GARCH model. For DCC model, the optimal allocation of gold in a telecommunication sector stocks/gold portfolio should be 2.98 cents and remainder 97.02 cents should be invested in telecommunication sector stocks. The ADCC and GO-GARCH models produce similar results but minimum and maximum values are different. These results emphasize the significance of portfolios which have mix assets class in order to minimize and downsize risk.

Table 4.34. Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Telecommunication / Oil				
DCC	0.11360	0.01982	1.04840	0.11380
ADCC	0.11320	0.01950	0.94770	0.11220
GO-GARCH	0.11350	0.01795	1.03740	0.11320
Telecommunication / Gold				
DCC	0.02784	0.00297	0.17600	0.02302
ADCC	0.02664	0.00173	0.17170	0.02257
GO-GARCH	0.02581	0.00433	0.16010	0.02133

Notes: The table reports the average optimal weight of oil and gold for an oil-telecommunication sector index and gold- telecommunication sector index portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; gold asset is represented by gold bullions price index, while the investment in stock is represented by the telecommunication sector index.

4.3.9 Utilities Sector

The table 4.35 reports the empirical results which produced GARCH type specification. With respect to mean equation in DCC and ADCC models, the estimated coefficient values of conditional mean (μ) are negative and also statistically insignificant. The estimated coefficient for AR term (a) in return generating process is negative and statistically significant which indicates that past realizations of utilities sector stocks returns do not facilitate to forecast the future stock returns, which confirming the finding of Arouri *et al.* (2011). The estimated values of coefficient (α) are statistically significant, indicating the evidence of short-term persistence of volatility. For variance equation, own GARCH effects (β) is statistically significant providing the evidence of long term persistence behavior in variances. The estimated value α is less than the estimated coefficient of β value, indicating that long-term persistence is greater than short term persistence. The estimated coefficients values (i.e., 3) of shape parameter (λ) for utilities sector index are less than the values of oil[12] and gold assets. The highest estimated values of shape parameter (i.e., 6) are observed for oil asset, whereas, the lowest values of estimated coefficient of similar parameter are reported for gold asset. Mainik *et al.* (2015) state that the assets having heavier tails indicates that the risk of portfolio and its upside potential which are driven by abnormal returns originate from assets returns with heavy-tail distribution. The analysis shows that oil with lower tails will not provide better diversification benefit as compared to gold asset.

[12] The values of oil and gold assets are reported with Basic Materials Sector results which all similar for all sectors.

Further, the estimated coefficient for the leverage effects (γ) is positive for utilities sector index, providing the evidence that negative innovations in assets' returns future volatility (variance) as compared to positive innovations in returns of the equal size. The findings indicate that the investors should search the hedge and safe haven instruments to provide a shelter to their investments during crisis period in market. The estimated coefficients on θ_1 and θ_2 are positive for utilities sector index, but only parameter θ_2 is statistically significant at the 1% level. The estimated sum values of θ_1 and θ_2 are less than unit, suggesting that dynamic conditional correlations are mean reverting. For GO-GARCH specification, the results for volatility persistence are in line with the findings of other two models. Lastly, each selection criterion in model diagnostic test indicates that DCC model is considered as best model.

Table 4.35. DCC, ADCC and GO-GARCH Parameters Estimates for Utilities Sector Index

	DCC			ADCC		
	Coef	SE	t-Statistics	Coef	SE	t-Statistics
μ	-0.0178	0.0199	-0.8943	-0.0293	0.0203	-1.4407
a	-0.0426***	0.0164	-2.5970	-0.0399***	0.0163	-2.4491
ω	0.2192***	0.0575	3.8147	0.2102**	0.0532	3.9486
α	0.1840***	0.0304	6.0583	0.1309**	0.0250	5.2296
β	0.8088***	0.0287	28.2080	0.8106**	0.0269	30.1117
λ	3.2315***	0.1602	20.1690	3.2495**	0.1618	20.0842
γ				0.1145**	0.0339	3.3756
θ1	0.0093*	0.0052	1.7980	0.0094*	0.0054	1.7519
θ2	0.9428***	0.0475	19.8359	0.9349***	0.0669	13.9677
θ3				0.0018	0.0060	0.3088
λ	5.0799***	0.1809	28.0839	5.1881***	0.1895	27.3803
Akaike	11.042			11.033		

Bayes	11.081	11.077
Shibata	11.042	11.033
H-Q	11.056	11.049
L-L	-21581	-21557

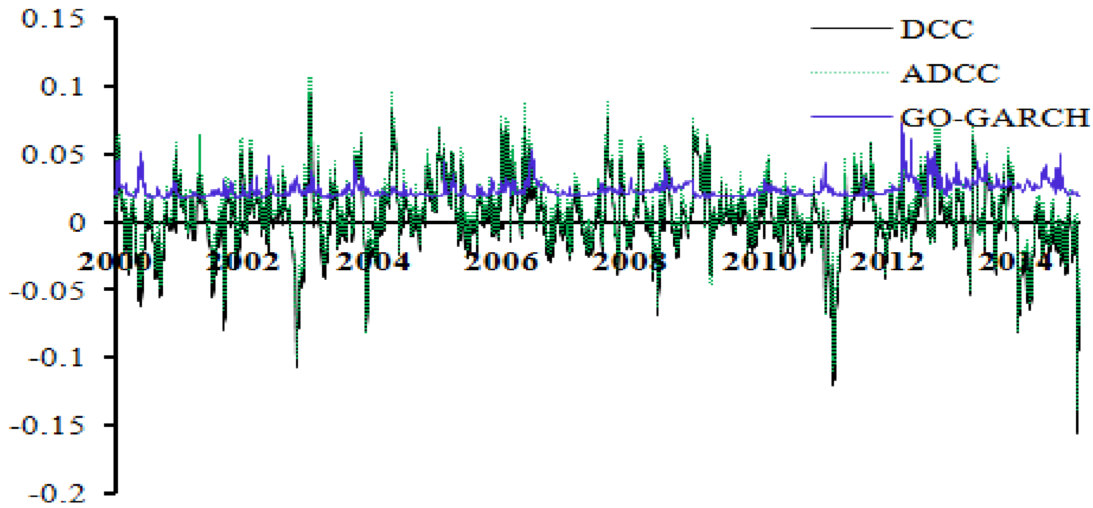
GO-GARCH Parameters	**Factor**
ω	0.0495
α	0.1608
β	0.8023
Skew	0.0672
λ	0.5865
L- L	-21385.5
No. of Obs	3913

Notes: The table provide notation μ for constant term in mean equation, autoregressive is shown with notation a, constant term in variance equation is indicated by ω, α represent the ARCH term, β shows GARCH term, λ is notation for shape parameter and γ indicate the asymmetric term. The parameters θ_1, θ_2 are for time-varying conditional correlations. Factor indicates the set of unobserved underlying factors in GO-GARCH model. H-Q indicates Hannan-Quinn and L-L show Log-Likelihood. The significance level at 1%,5% and 10% is shown by an asterisk (***,**,*).

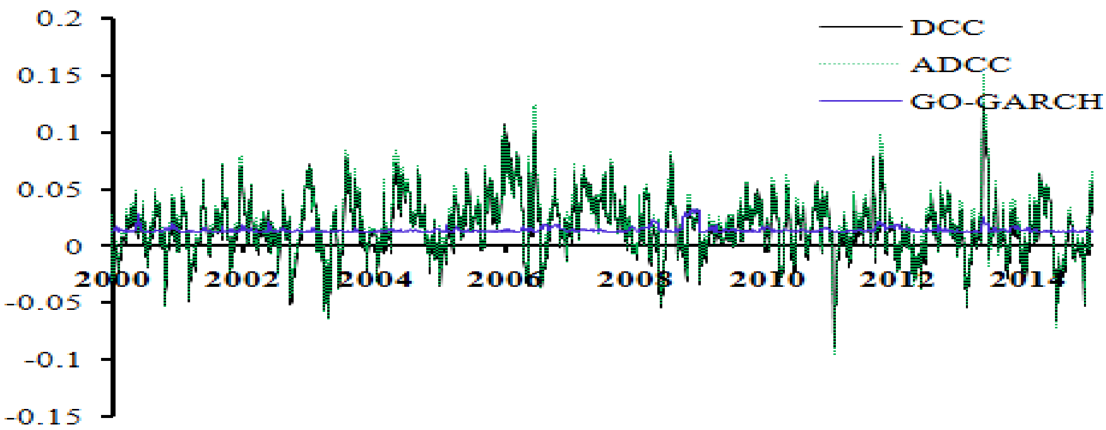
4.3.9.1 Time Varying Conditional Correlations

The dynamic conditional correlations presented in figures 4.25a, b, are estimated by three different multivariate GARCH models. It is interesting to note that all models show a different pattern in correlations over the study period. Consequently, dynamic conditional correlations estimated through DCC model are highly correlated with ADCC model's correlations. Whereas, conditional correlations produced from GO-GARCH model are uncorrelated with the ones DCC and ADCC models. A significant positive variation in correlations is established for all models. Additionally, large drop in correlation values (i.e.-0.16) originate at the end of 2014 for utilities sector index and oil pair. A large upward and downward pattern in correlations exhibits that there is no clear constant increase and decrease trend in conditional correlations for utilities sector index and oil. Further, a positive trend in correlations for utilities sector index and gold pair is noticed on average from all models.

a) Dynamic Conditional Correlations: Utilities Sector Index and Oil



b) Dynamic Conditional Correlations: Utilities Sector Index and Gold



Figures 4.25a, b. Time varying correlations among Utilities Sector Index, oil and gold pairs

4.3.9.2 Correlation between Correlations

The correlations produced from all three models are shown in table 4.36. This shows that correlations obtained from DCC and ADCC model are significant similar, almost close to one. Whereas, the correlations obtained from DCC/GO-GARCH and ADCC/GO-GARCH are different on comparison because of different news impact surface correlations. Similar results are obtained in figures 4.26a, b and c. In figures 4.26a, b, along z_1 axis (utilities sector index) surface correlation between basic material sector index and oil/gold asset shows a negative to positive relationship. Along the z_2 axis (oil and gold assets) the surface correlations trace out a positive to negative association. For DCC and ADCC models, the shocks to stocks, oil, and gold have asymmetric effects on the correlations between all assets. For GO-GARCH model, it is found that correlations for all assets remain negative and shocks relate to the factors only (figure 4.26c). Moreover, the symmetric effects of shocks are expected in GO-GARCH model because factors are orthogonalized in this model.

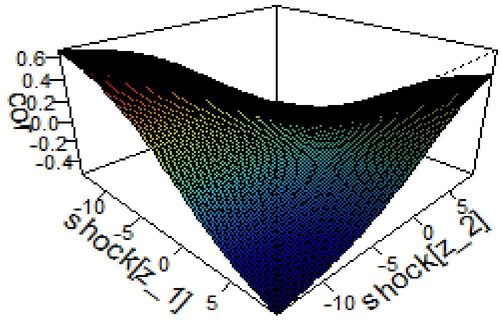
Table 4.36. Correlation between Correlations DCC,ADCC and GO-GARCH Models

	Utilities Sector / Oil	Utilities Sector / Gold
DCC / ADCC	0.9926	0.9926
DCC / GO-GARCH	0.0460	0.0701
ADCC / GO-GARCH	0.0500	0.0866

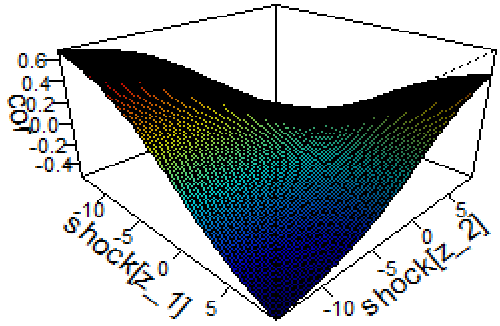
Notes: The DCC and ADCC models are estimated through multivariate t distribution (MVT). The GO-GARCH model is estimated through multivariate affine negative inverse Gaussion (MANIG) distribution.

a) News Impact Correlation Surface between Utilities Sector Index, Oil and Gold-DCC

i) Oil

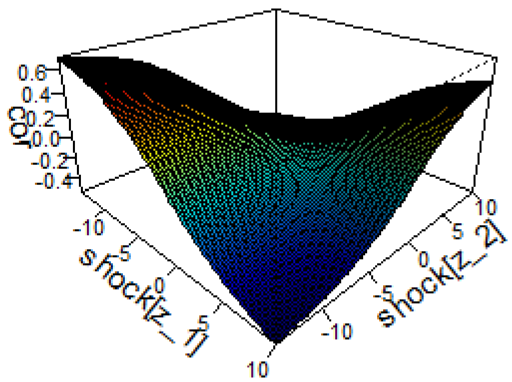


ii) Gold

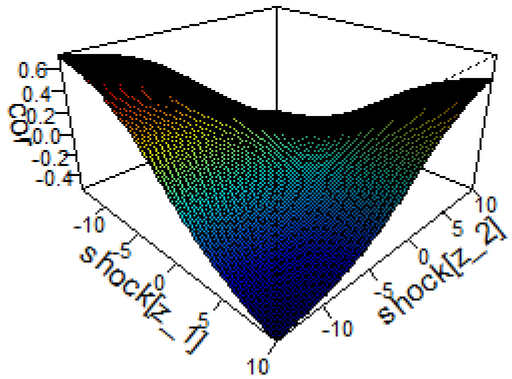


b) News Impact Correlation Surface between Utilities Sector Index, Oil and Gold - ADCC

i) Oil

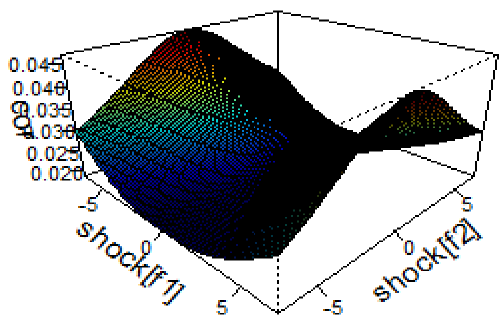


ii) Gold

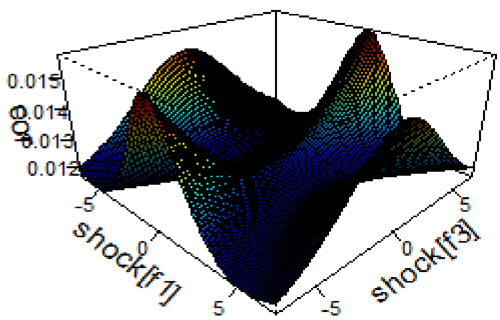


c) News Impact Correlation Surface between Utilities Sector Index, Oil and Gold - GO-GARCH

i) Oil



ii) Gold



Figures 4.26a, b, c. News impact surface correlations between Utilities sector index, oil and gold assets

4.3.9.3 Optimal Hedging Strategy in Utilities Sector Index with Oil and Gold Assets

The hedge ratio summary for utilities sector index and oil/gold pairs are reported in Table 4.37. The DCC and ADCC model provides mean value i.e. 0.00410 of hedge ratio between utilities sector/oil, suggesting that on average, for 1 dollar long position in utilities sector can be hedged with 0.41 cents by taking short position in oil market. Moreover, GO-GARCH provides the highest hedge ratio on average, indicating that for a one dollar long position in utilities sector can be hedged with 2.57 cents by taking short position in oil. By comparing, gold provides highest hedging benefits computed through all models. Accordingly, the hedge ratio between utilities sector index/gold is 0.03373 on average computed from DCC model indicating that for a 1 dollar long position in utilities sector stocks can be hedged with 3.37 cents by taking short position in gold market. The ADCC and GO-GARCH models produce hedge ratios i.e. 0.04147 and 0.02671 on average respectively, providing that for a 1 dollar long position in utilities sector stocks can be hedged with 4.15 cents and 2.67 cents by taking short positions in gold. Finally, figure 4.27a, b provide a graphical presentation of hedge ratios among utilities sector index and oil/gold pairs. All hedge ratios are developed through multivariate GARCH models providing that the optimal hedge ratios are time variant. On average, there is a positive trend in hedge ratios among utilities sector index and oil/gold pairs across the study period.

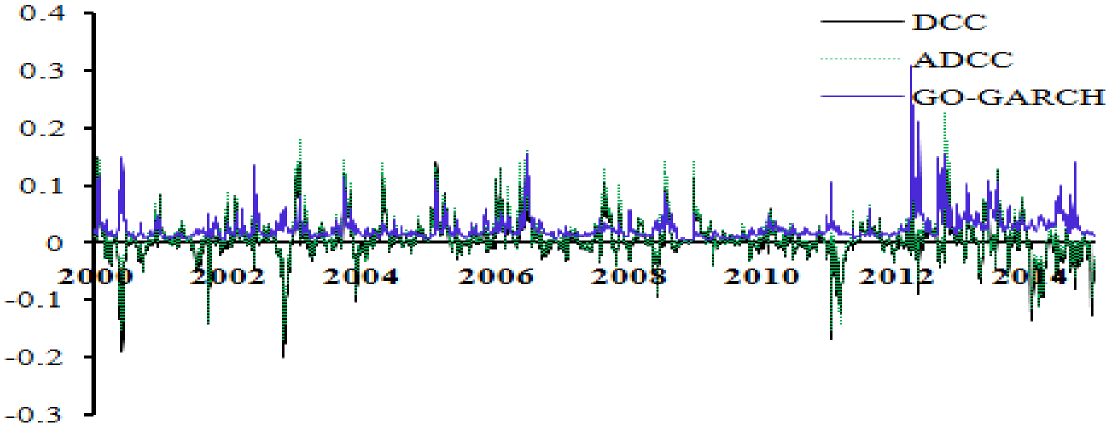
Table 4.37. Hedge Ratio (long / short) Summary Utilities Sector Index

	Mean	Minimum	Maximum
Utilities / Oil			
DCC	0.0041	-0.20083	0.2324
ADCC	0.00959	-0.1679	0.2244
GO-GARCH	0.0257	0.00645	0.3088

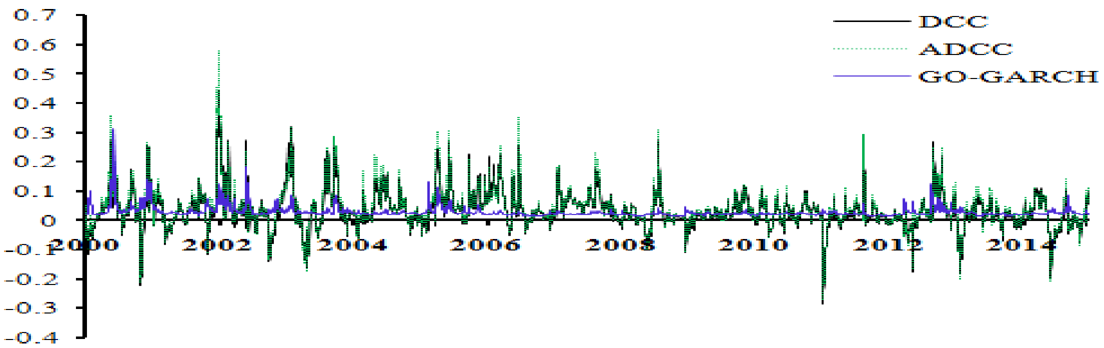
Utilities / Gold			
DCC	0.03373	-0.28651	0.4457
ADCC	0.04147	-0.27171	0.5762
GO-GARCH	0.02671	0.01412	0.3118

Notes: The table reports the hedge ratios for oil-utilities sector index and gold-utilities sector index portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the utilities sector index.

a) Optimal Hedge Ratio: Utilities Sector Index and Oil



b) Optimal Hedge Ratio: Utilities Sector Index and Gold



Figures 4.27a, b. Dynamic Hedge Ratios among Utilities Sector Index, oil and gold pairs

4.3.9.4 Portfolio Implication of oil and gold assets with Utilities Sector Index

Table 4.38 presents the descriptive statistics of the optimal investment weights for a utilities sector stocks and oil/gold pairs. The optimal allocation of oil in a utilities sector stocks-oil portfolio should be 11.24 cents and remaining 88.76 cents should be invested in utilities sector stocks as computed through DCC. For ADCC model, the optimal portfolio weight is 0.1119 on average, indicating that for a one dollar portfolio, investors should invest 88.68 cents in utilities sector stocks and 11.19 cents should be invested in oil market on average. Besides, GO-GARCH model provide least optimal weight of utilities sector and oil portfolio. As compared to oil asset, the optimal allocation for gold asset is 2.79 cents in utilities sector stocks and remainder 97.21 cents should be invested in utilities sector stocks estimated form DCC specification. Moreover, ADCC and GO-GARCH models produce different results. These results underline the role of alternative assets or commodities in traditional portfolio of stocks to minimize risk.

Table 4.38. Portfolio Weights Summary

	Mean	Minimum	Maximum	SD
Utilities / Oil				
DCC	0.11240	0.01912	1.01430	0.11180
ADCC	0.11190	0.01879	0.91160	0.11050
GO-GARCH	0.11000	0.01802	0.99940	0.10860
Utilities / Gold				
DCC	0.02792	0.00484	0.17390	0.02354
ADCC	0.02682	0.00375	0.17280	0.02304
GO-GARCH	0.02639	0.00480	0.16260	0.02166

Notes: The table reports the average optimal weight of oil and gold for an oil-utilities sector index and gold- utilities sector index portfolios using conditional variance and covariance estimated from DCC, ADCC and GO-GARCH models. The WTI crude oil index is used for oil asset; the gold asset is represented by gold bullions price index, while the investment in stock is represented by the utilities sector index.

4.4 Results Discussion and Suggestions

Taking a close look, the unconditional correlations of sectoral stock indices, oil/gold pairs differ substantially across the economic sectors. The correlations between oil and sector stock returns are weak on average and relatively positive, except consumer services, consumer goods and telecommunication sector. This suggests that, in theory, there is high short or long term benefit to diversifying over basic material, financials, health care, industrials, oil and gas, and utilities sector. Furthermore, investors can achieve diversification benefit by allocating some of their funds in oil market. This finding also suggests that oil price increases over the study period is likely to be seen as an indicator of higher expected corporate earnings in these sectors. For gold and industry sector stocks' returns, the correlations are weak on average and surprisingly positive, except for consumer goods, health care, oil and gas, and telecommunication. This also suggests that there is high short or long term benefit of diversifying over these sectors with gold asset. For consumer goods, health care, oil and gas, and telecommunication, the correlation values are weak negative on average suggesting that there is short or long-term diversification benefit of gold over these sectors.

Looking towards empirical analysis, this thesis uses the multivariate GARCH models namely; DCC-GARCH, ADCC-GARCH and GO-GARCH models. These models face the challenge of curse of dimensionality with large data set but also present the time series symmetry features, to capture the volatility persistence and dynamic relationships between industrial sector indices and commodities. The volatility persistence, i.e., short range and long range persistence is evident of volatility clustering or market momentum, which is common feature of financial returns series (Ogum, 2001; Chinzara, 2011). The long-term volatility persistence is greater than the short-term persistence in all considered markets. It is inferred that conditional volatility does not change very rapidly under the impulsion of returns innovations. They tend to fluctuate gradually over time with respect to substantial effects of past volatilities. This is consistent with the finding of Arouri *et al.* (2011) in stock sector returns for the United States and Europe. The results of GO-GARCH model for volatility persistence are in line with the findings of DCC and ADCC models, indicating that long-term persistence significantly higher than the short-term persistence. These evidences show that, investors and portfolio managers will only earn high returns on investment in the short run and lose their investments for long time. These findings also suggest that, investors and fund managers seeking profit from trading oil, gold, and stocks at sector level in Pakistan may consider active investment strategies based on current market trends and volatility persistence. It would be advisable to increase the portfolio investment if markets are rising, and to reduce the portfolio investment if markets are falling. All while keeping in mind the viability of such strategies depends on the stability and the strength of performance between successive periods.

It is enormously important to investigate the first object of the study which is based on the asymmetric dynamics of the considered markets indicating that negative shocks tend to be followed by volatility in future more than positive shocks of equal size. The positive leverage effect of industrial sector indices and oil asset signifies that negative shocks in stocks and oil prices increase the conditional volatility. By comparing with gold, this effect is negative suggesting that negative shocks in gold prices tend to decrease the volatility. The different asymmetric effect arise because of heterogeneity, arbitrage activities, contract liquidity, or/and asymmetric information, consistent with the findings of Basher & Sadorsky (2016) and Raza (2017). These findings recommend that investors and portfolio managers should emphasis on volatility relationship while making the portfolio decisions (Chkili, 2016).

Secondly, this study aims to explore the time-varying dependency between stock, oil and gold assets. To find this, the sum of effects of previous shocks (θ_1) and past lagged dynamic conditional correlations (θ_2) on the present dynamic conditional correlations for all pairs are less than one, showing that mean reverting behavior of conditional correlations is observed across assets' returns under consideration. The conditional correlations between industrial sectors indices and oil/gold pairs produced from DCC and ADCC specifications provide a similar pattern but GO-GARCH model's correlations are uncorrelated with other two techniques. A part of the third object of the study is to securitize the safe haven properties of oil and gold assets. To identify this, a safe haven feature of oil and gold assets are short lived during the financial turbulence 2007-2009 and vary across all industrial sectors. The findings indicate that oil serves as potential safe haven asset for investors only for health care sector stocks. In case of gold asset, it is financial protector for all sector stocks except telecommunication and utilities sectors.

The next step towards the third and fourth objectives of the study, the hedge ratios for industrial sector indices and oil/gold pairs suggest that allocation of oil/ gold assets in portfolio of stocks at sector level in Pakistan provide a hedging benefit in stock market against investment loss. Moreover, on the average, oil provides cheapest hedge as compared with gold (Sadorsky, 2014a) because the values of hedge ratio between industrial stock indices and oil pairs are lowest then industrial stock indices and gold pairs. For the investors, who are seeking the higher risk-returns tradeoff from investment at sector level stocks, the finding of this thesis provide important implications to hedge the downside risk of the portfolio. The findings of thesis suggest that investors need more gold than oil asset in order to minimize the risk. In mixed assets portfolio, risk of stocks investment can be hedged with low hedging cost by taking a short position in oil or gold markets. These results reconfirm the findings of Arouri *et al.* (2015). In addition, the hedging dynamics of oil and gold assets are different across all industrial sectors in Pakistan. Therefore, in order to minimize the risk without reducing or for a given level of expected returns, it would be advisable that investors should hold small portion of oil and gold assets in their portfolios than stocks at sector level, which is consistent with findings of Arouri *et al.* (2011, 2012) at sector level equities. Furthermore, investors should update their hedging position regularly according to market bull and bear conditions. These results also increase the importance of mixed assets portfolio and support conventional perception that allocation of oil and gold assets into well diversified portfolio of stocks increase the risk adjusted performance of the considered portfolio (Chkili, Aloui, & Nguyen, 2014; Hammoudeh *et al.*, 2009; Chang *et al.*, 2010).

Finally, in search of last objective of the study, the significance of oil and gold assets is evaluated to assess the possible reduction of portfolio risk while adding in traditional portfolio of stocks at sector level in Pakistan. The results indicate that oil and gold assets have potential benefits to reduce the risk when added in portfolio of stocks. Moreover, the effectiveness of these alternative assets in risk reduction varies across industrial sector stocks. Findings of the thesis highlight the importance of mixed assets portfolio (stocks and commodities) in order to reduce the risk. These findings suggest that portfolio managers rebalance their portfolios by selling over-weighted asset and buying underweighted asset on the basis of average weight of assets in portfolio (Kumar, 2014). For model selection, all multivariate models are compared based on model diagnostic test and specifies that DCC model significantly outperforms as compared with other two models.

CHAPTER 05

5.1 Conclusion and Policy Implication

This thesis attempts to investigate the dynamics of returns and volatilities, hedging and portfolio implication of oil, gold investments in Pakistani stock market by using the DCC-GARCH, ADCC-GARCH and GO-GARCH specifications for sample period January 2000 to December 2014. The study carried out industrial sector analysis with an aim to counter the biases inherent to the use of aggregate stock index that may mask the sector specific characteristics. The results demonstrate that industrial sectors' stocks outperformed with highest return followed oil & gas and consumer services industrials' sectors. This study finds worst performance of telecommunication sector in Pakistan caused by severe effect of the Global Financial Crisis 2007-2009. Findings of this study corroborate literature showing a negative return in Telecommunication sector in the United States such as Arouri *et al.* (2011). In commodity market, gold experienced highest return when compared to oil asset during the entire period of the study. Daskalaki and Skiadopoulos (2011) and Jensen *et al.* (2000) also indicate that on comparative basis, gold provides higher returns than other commodities. By comparing with oil, the gold (due to its features of low volatility) manifests its importance as a monetary component and therefore, is sparingly used in exchange market interventions (Hummoudeh, Malik, & McAleer, 2011). The employed diagnostic test indicates that DCC-GARCH is better as compared to the other models.

The results of all multivariate GARCH models demonstrate that long term volatility persistence is greater than short term volatility persistence indicating that conditional volatility does not change very rapidly under the impulsion of returns innovations. They tend to fluctuate gradually over time with respect to substantial effects of past volatilities. This shows that investors and portfolio managers will only earn a high returns on investment for short time but they will lose their investments for long time. The results for asymmetric volatility dynamics reveal that negative innovations in returns for all series except for gold asset tends to increase the conditional volatility in future more than positive innovations of the same magnitude. Furthermore, the correlation patterns among assets returns provide a mean reverting behavior across all industrial sector stocks-oil/gold pairs over the time. The time-varying patterns of conditional correlations between all pairs help to examine the hedge on average and safe haven properties of oil and gold assets during turbulence time in stock market. In addition, a downward pattern in correlations has been found during the economic downturns which displays that oil is a safe haven asset for health care sector stocks, while gold acts a safe haven asset for all sectors' stocks except telecommunication and utilities sectors.

Furthermore, with respect to portfolio management, this study scrutinizes the hedge ratios and optimal weights to minimize the portfolio risk. The results for industrial sector stocks and oil/gold portfolios indicate that adding oil and gold assets into portfolio of industrial sectors' stock improves the overall risk-adjusted return performance. For instance, investors in Pakistan should allocate more stock than oil and gold assets in their portfolios and investment risk in stock market can be hedged by taking the short position in oil and gold markets. These hedging dynamics of oil and gold assets are different across all industrial sectors suggesting that investors should make sector base policy while allocating oil and gold assets into well diversified portfolio of sectoral stocks in Pakistan. Finally, a time-varying pattern in hedge ratios for all sectors indicates that investors should update their hedge position regularly according to market conditions. In case of allocation weights of oil and gold assets for sectoral stocks, the results indicate that oil and gold assets have potential benefits to reduce the risk when added in portfolio of stocks. Furthermore, the effectiveness of these alternative assets in risk reduction varies across industrial sector stocks.

These results provide important policy implication for policy makers, investors, portfolio managers, and commodity market participants dealing with Pakistan Stock Exchange (PSX). Based on empirical results, the study highly recommends that policy makers should seriously consider the oil price shocks because oil prices shocks influence inflation, stock market at national level and sector level. Rather than monetary policy, Pakistan should rely more on its fiscal policy for oil shocks absorption as oil prices influence the stock market and inflation. In the event of higher oil prices, an expansionary fiscal policy could be considered in order to deal with supply side inflation pressures.

The study recommends that without putting economic development aside, the policy makers should use specific tools in order to mitigate the negative impacts of higher oil prices. The government should implement solid measures to cope with high oil prices. First, government should deregulate the oil market so that the oil price changes should benefit the consumers at large. Second, government should establish a strategic stock to mitigate the adverse impact of oil prices. The government can purchase and preserve crude oil when prices are low and should make available when market is high or there is a shortage in supply. The study emphasizes that it is appropriate for government agency to hedge product oil prices in future to overcome fluctuations. Another important measure for policy makers to reduce the negative impact of oil shocks is to diversify into non oil energy sources or common alternatives such as hydro-power, geothermal, solar energy, wind power and bio-fuels for traditional transportation.

The results of the study also contain implications for investors and portfolio managers for risk hedging and portfolio management. However, investors and portfolio managers dealing with Pakistan Stock Exchange (PSX) as well as Pakistan Mercantile Exchange (PMEX) should take more stocks than oil, and gold assets into portfolio of stocks which can improve the overall risk-adjusted performance of their portfolios. Furthermore, the stock market risk can be hedged by taking short positions in oil and gold markets and more interest in stock market. Finally, the major policy implication of this thesis is that volatility of gold is least and its return is high as compared to oil asset. The study implies that the investors should prefer more gold than oil in portfolio of stocks.

5.2 Future Directions for Research

The results of thesis open diverse points of discussion for future research on commodity market and stock market. Considering, this research can be employed to evaluate all other commodities traded in Pakistan Mercantile Exchange (PMEX) for hedge and safe haven investigation. Although, this study only focuses on two commodities, i.e., oil and gold. Further, one could analyze the specific commodity in the related countries like natural gas in Russian market and oil in Saudi Arabia. Moreover, the study recommends that future researchers should take commodity index into consideration for portfolio construction. This study has included two assets in portfolio construction; researcher can extend the study in future by adding more than two commodities in the portfolio of stocks. Further avenue of the study for researchers is to access the effects of alternative assets' shocks on bonds market and to compare them with the effect of both commodities on stocks markets. Doing so, the research in future may provide the knowledge about relationship of oil, gold with bonds and would suggest whether gold and oil are efficient for portfolio diversification with bonds.

The results of this thesis may be sensitive to data frequency. So, it would be appropriate to consider other data frequency e.g. weekly data since significantly reduces the biases that may arise due to as non-synchronous trading days and bid-ask effect (Arouri & Nguyen, 2010). It will also provide the opportunity to examine the robustness of our results with respect to data changes. In the literature, the correlation between equities and commodities is negative but findings of this study indicate that the correlations are not always negative because correlation among equities and commodities like oil and gold fluctuate over time. Future researchers can further investigate to evaluate why these correlations are not always negative. Along with these directions, the future researchers can employ this research methodology in a new vista, that is, rolling window analysis. It would be appropriate use rolling values of correlations in order to understand how hedge ratios and portfolio weights change over time for returns and volatility. Finally, in the current analysis, we employed in-sample optimal portfolio weights and hedge ratios; however, it would be interesting if future researchers could use out-of-sample optimal portfolio weights and hedge ratios. This can be helpful for investors in decision making.

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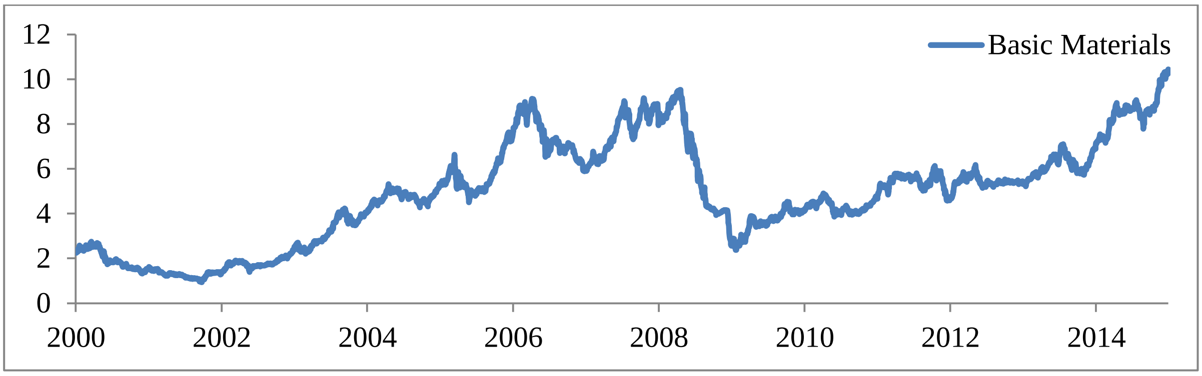
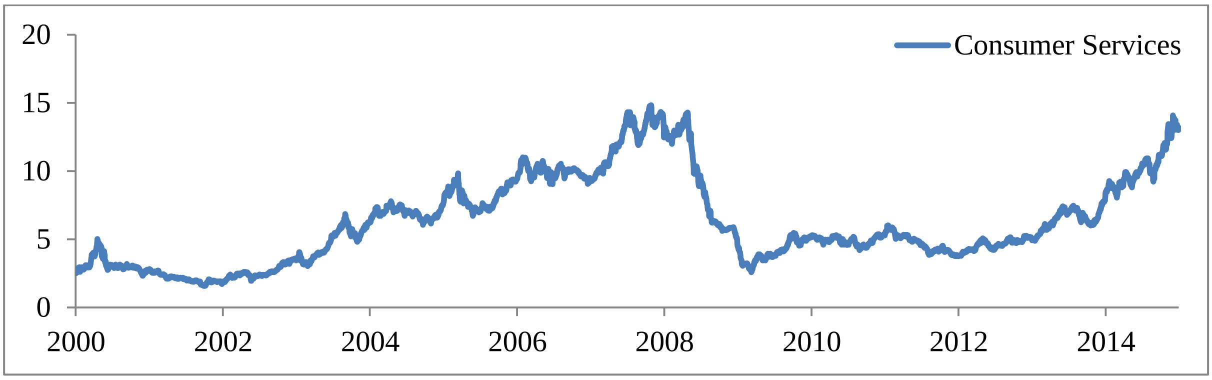
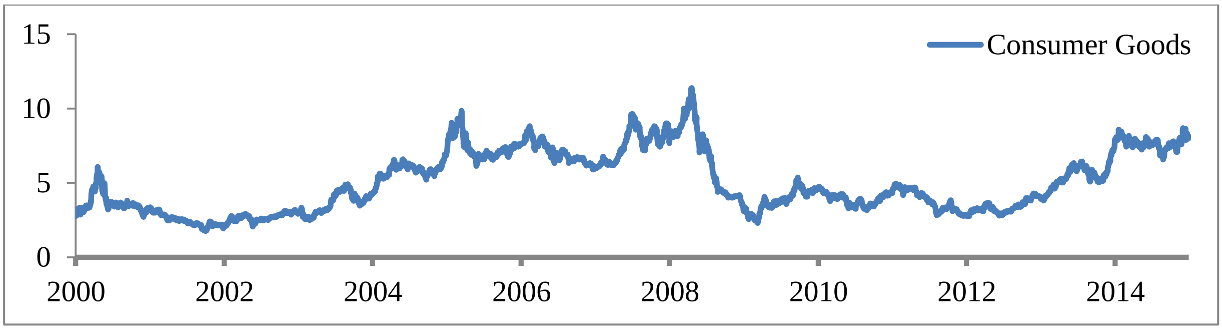
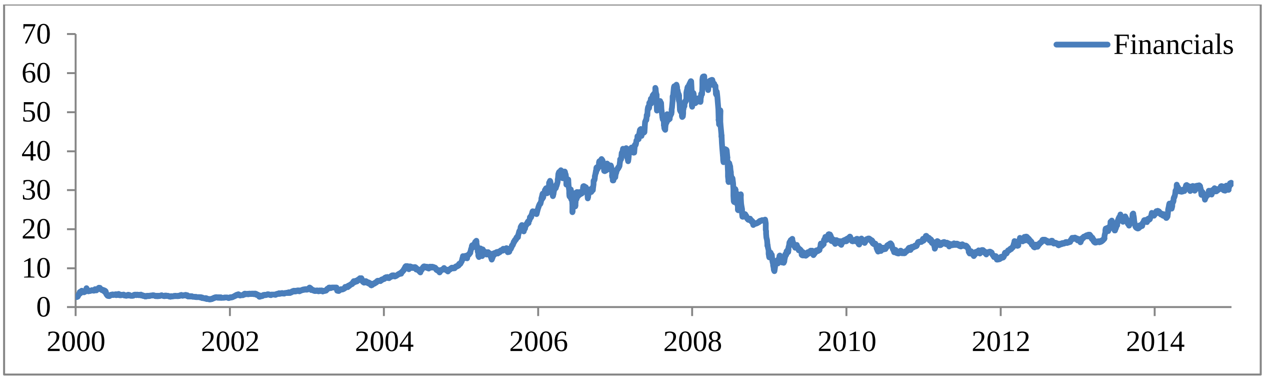
Appendix-A (Time Series Trend)





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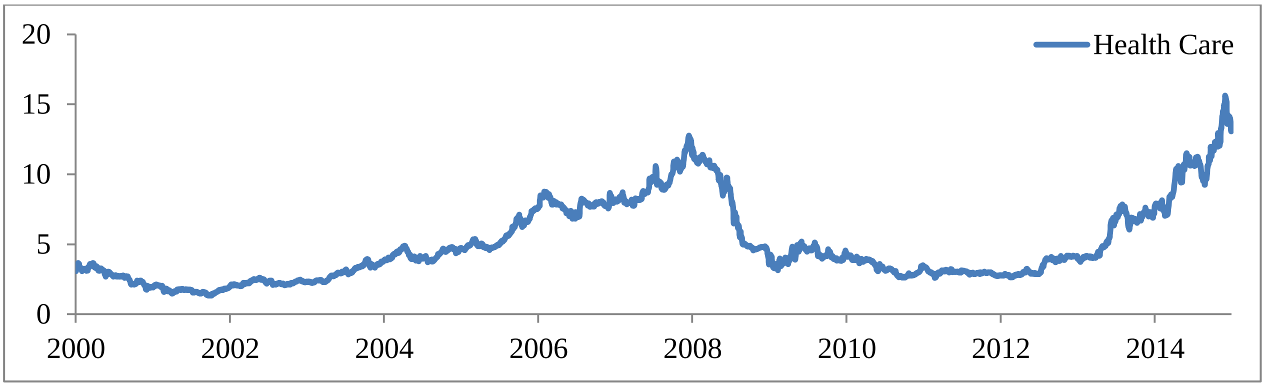
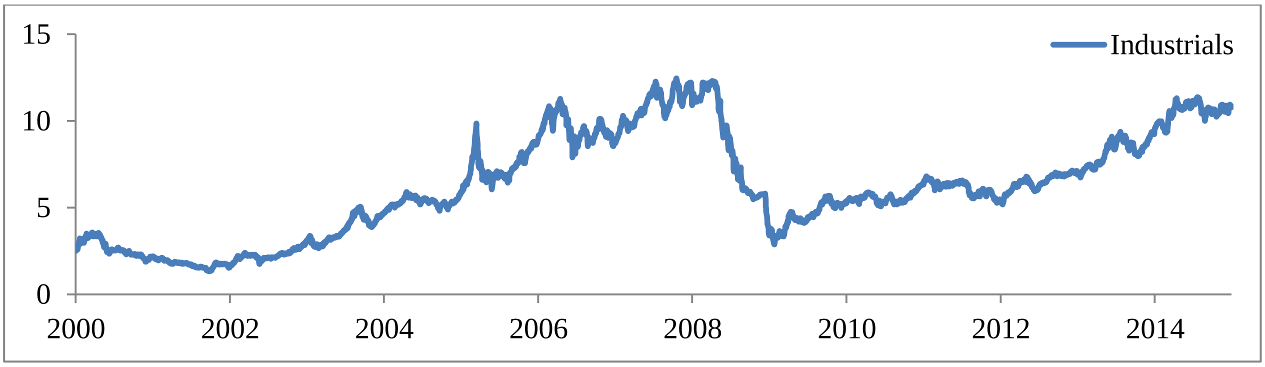
0
10
20
30
40
50
60
70
2000
2002
2004
2006
2008
2010
2012
2014


Health Care
0
5
10
15
20
2000
2002
2004
2006
2008
2010
2012
2014


Industrials
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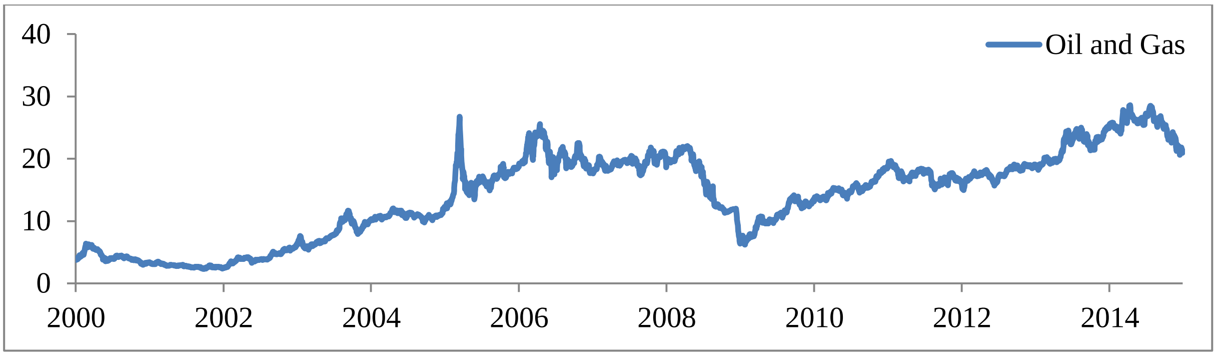
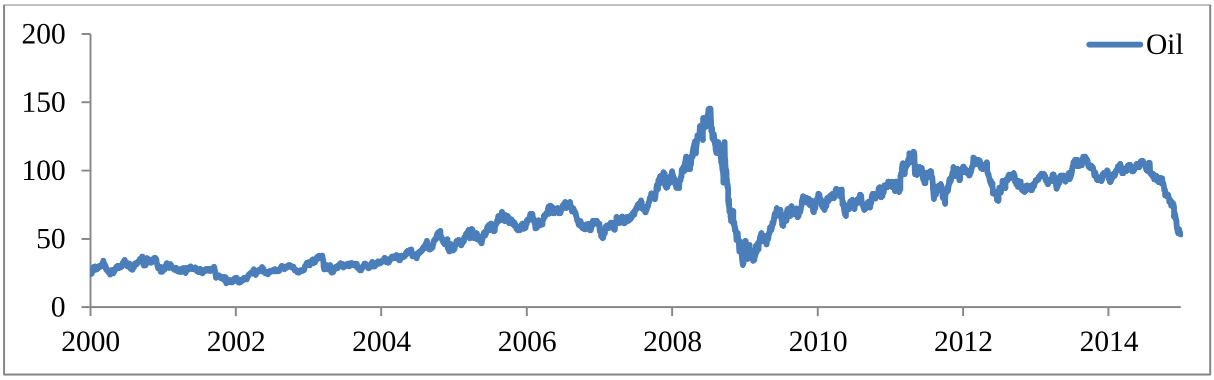
15
2000
2002
2004
2006
2008
2010
2012
2014


Oil and Gas
40
30
20
10
0
2000
2002
2004
2006
2008
2010
2012
2014


Telecommunication
4
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
2014


Utilities
6
5
4
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
2014


Oil
200
150
100
50
0
2000
2002
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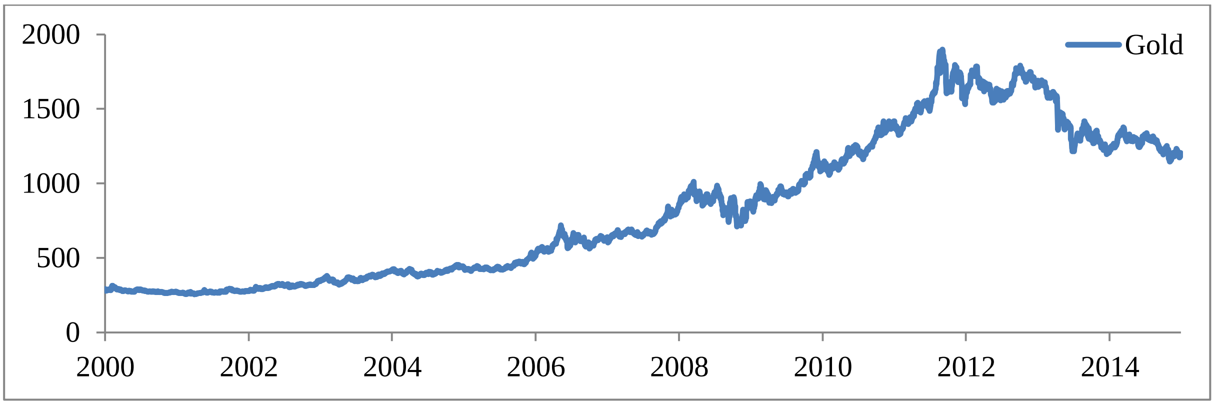
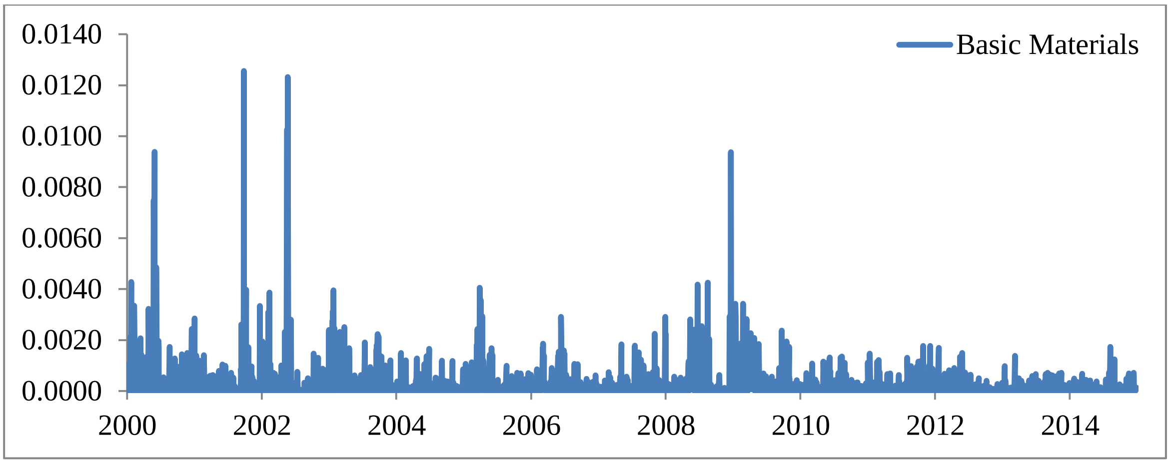
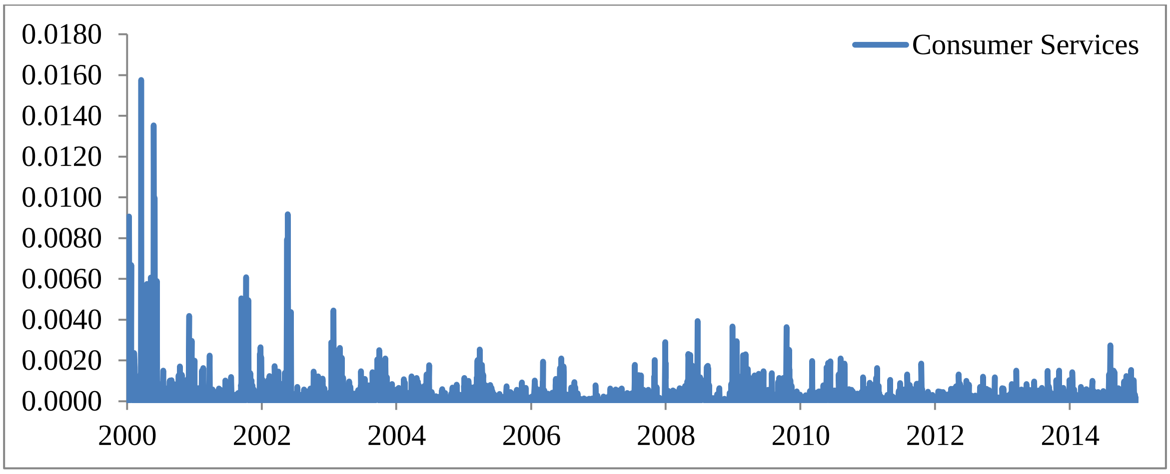
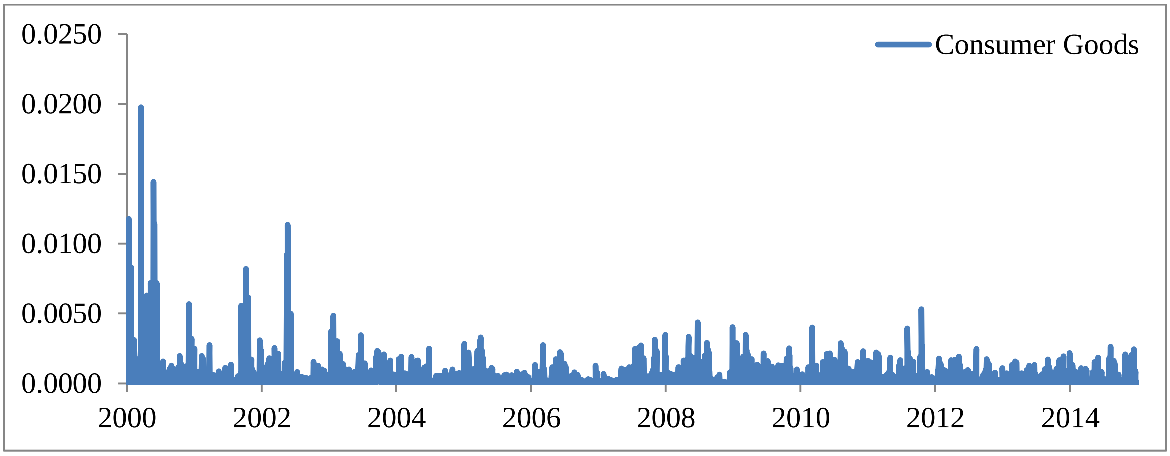
2006
2008
2010
2012
2014

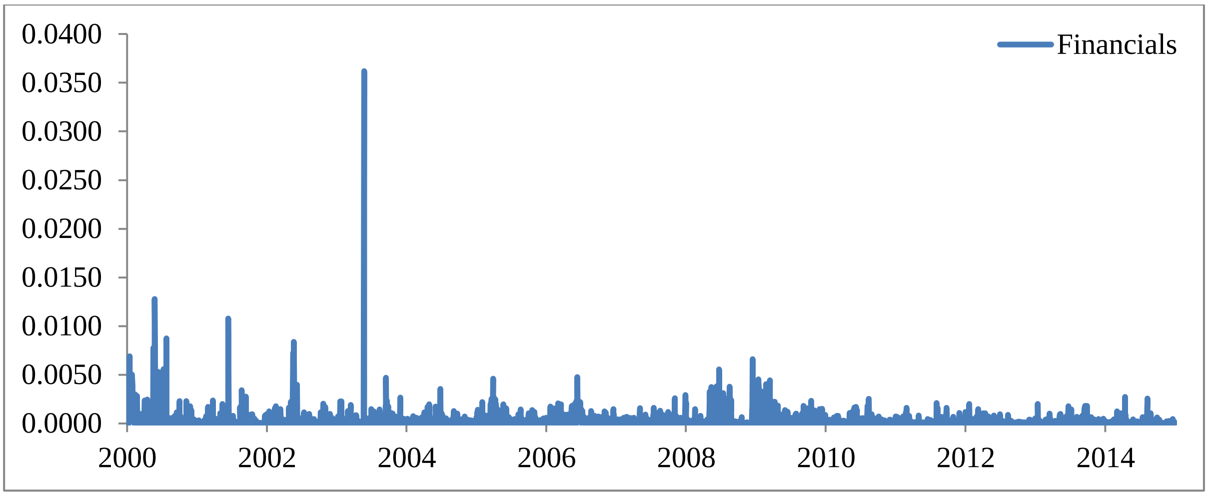

Gold
2000
1500
1000
500
0
2000
2002
2004
2006
2008
2010
2012
2014

Appendix-B (Squared Returns Graph for all series)





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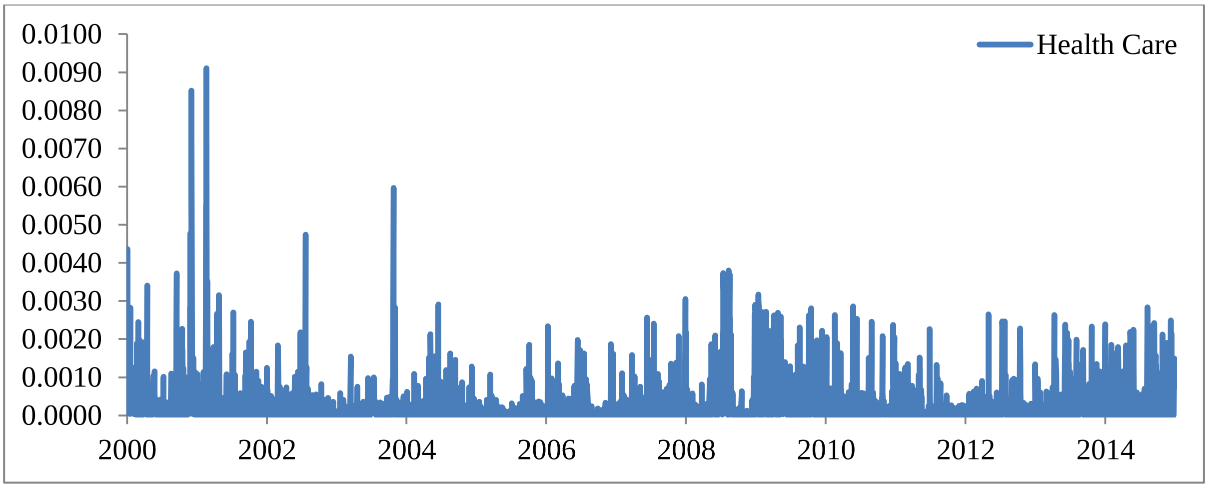
0.0350
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
2000
2002
2004
2006
2008
2010
2012
2014
Financials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0.0060
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0.0030
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0.0010
0.0000
2000
2002
2004
2006
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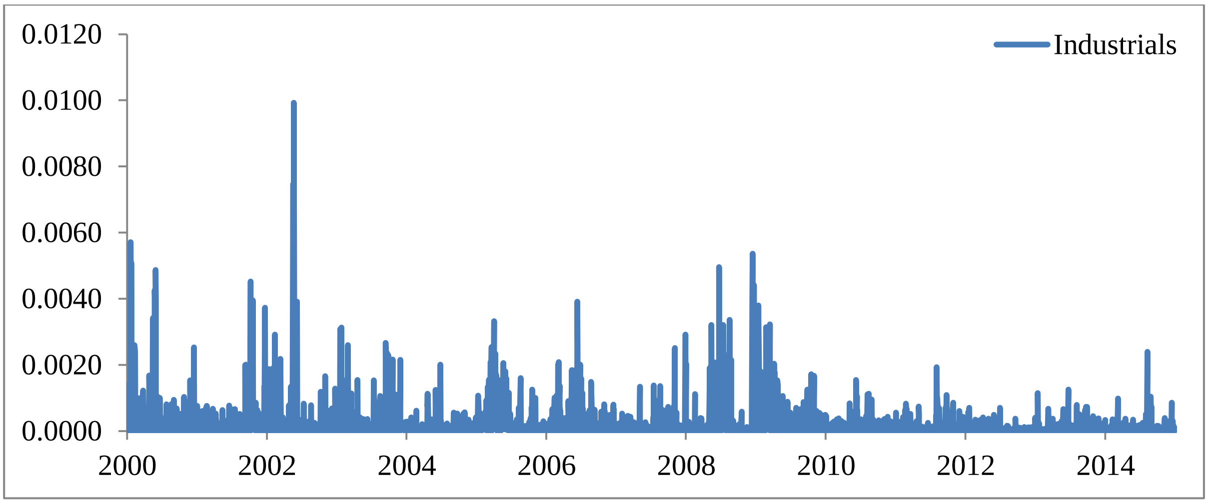
2010
2012
2014
Health Care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0.0060
0.0040
0.0020
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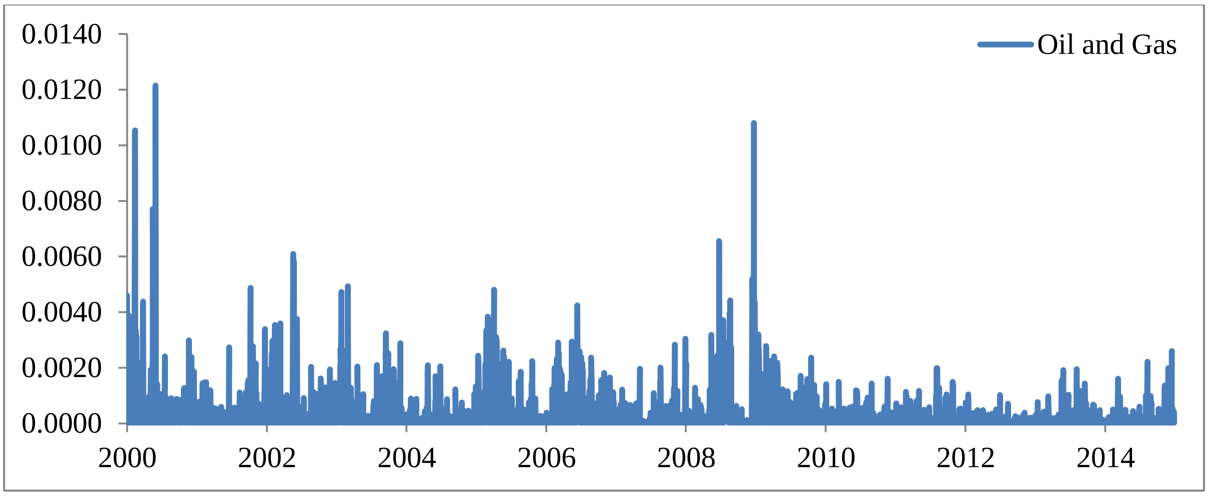
2010
2012
2014
Industrials


Oil and Gas
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
2000
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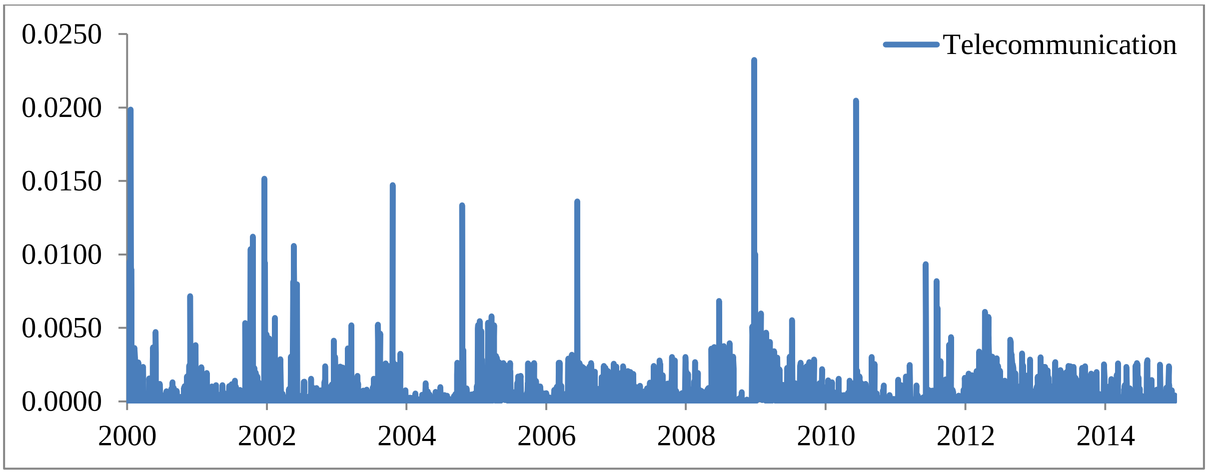
2010
2012
2014


Telecommunication
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
2000
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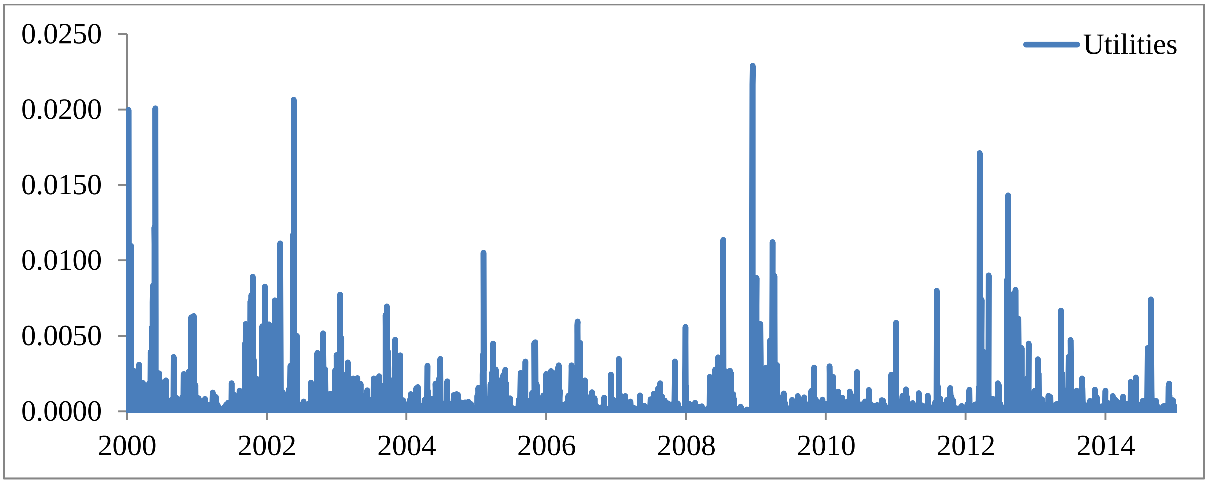
2014


Utilities
0.0250
0.0200
0.0150
0.0100
0.0050
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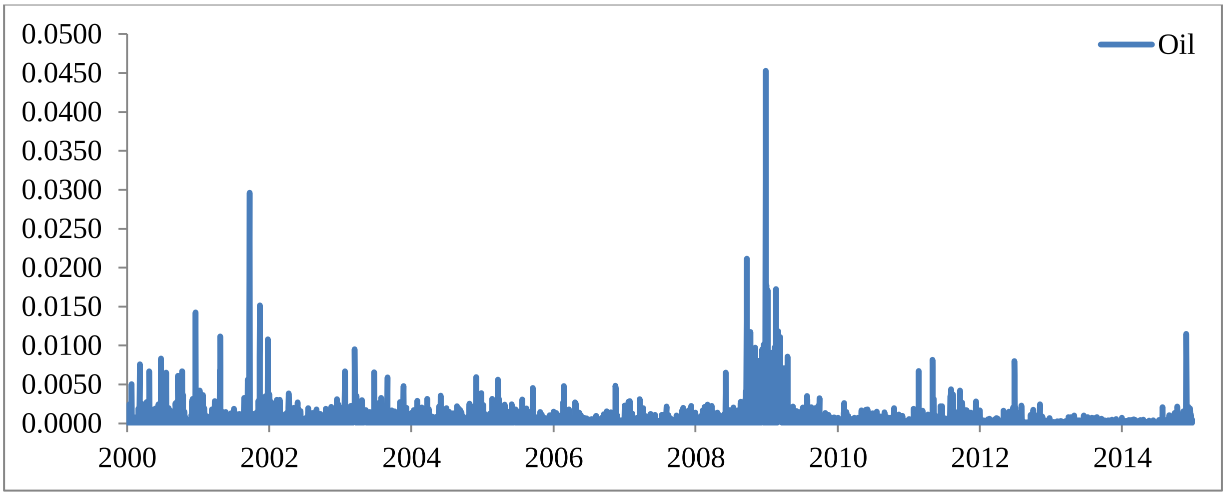
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0.0300
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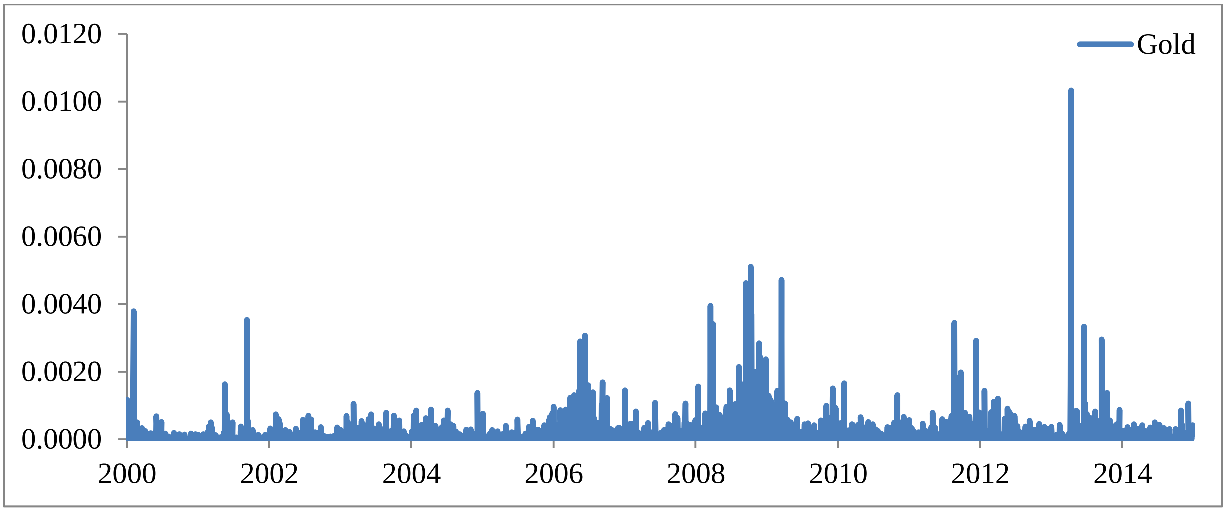
Oil


0.0120
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0.0060
0.0040
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2010
2012
2014
Gold

Appendix-C (Four Specifications of the DCC Model)

Basic Materials
Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.522	10.527	10.717	10.719
Bayes	10.561	10.560	10.749	10.747
Shibata	10.522	10.527	10.717	10.719
Hannan-Quinn	10.536	10.539	10.728	10.729
Log- Likelihood	-20562	-20575	-20948	-20956
No. Obs	$3,913.00	$3,913.00	$3,913.00	$3,913.00

Consumer Services
Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.606	10.621	10.782	10.797
Bayes	10.644	10.654	10.814	10.824
Shibata	10.605	10.621	10.782	10.796
Hannan-Quinn	10.619	10.633	10.793	10.806
Log- Likelihood	-20726	-20758	-21075	-21106
No. Obs	3913	3913	3913	3913

Consumer Goods
Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	11.001	11.009	11.170	11.178
Bayes	11.039	11.043	11.202	11.205
Shibata	11.001	11.009	11.170	11.178
Hannan-Quinn	11.014	11.021	11.181	11.188
Log- Likelihood	-21499	-21519	-21834	-21853
No. Obs	3913	3913	3913	3913

Financials

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.701	10.713	10.971	10.980
Bayes	10.740	10.747	11.003	11.007
Shibata	10.701	10.713	10.971	10.980
Hannan-Quinn	10.715	10.725	10.983	10.990
Log- Likelihood	-20913	-20940	-21445	-21466
No. Obs	3913	3913	3913	3913

Health Care

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.662	10.672	10.855	10.865
Bayes	10.700	10.706	10.887	10.892
Shibata	10.662	10.672	10.855	10.865
Hannan-Quinn	10.675	10.684	10.866	10.875
Log- Likelihood	-20835	-20860	-21217	-21240
No. Obs	3913	3913	3913	3913

Industrials

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.349	10.352	10.552	10.554
Bayes	10.387	10.386	10.584	10.581
Shibata	10.349	10.352	10.552	10.554
Hannan-Quinn	10.363	10.364	10.564	10.564
Log- Likelihood	-20224	-20233	-20626	-20632
No. Obs	3913	3913	3913	3913

Oil and Gas

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	10.707	10.709	10.907	10.908
Bayes	10.746	10.743	10.939	10.935
Shibata	10.707	10.709	10.907	10.908
Hannan-Quinn	10.721	10.721	10.918	10.918
Log- Likelihood	-20925	-20931	-21319	-21324
No. Obs	3913	3913	3913	3913

Telecommunication

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	11.281	11.283	11.520	11.521
Bayes	11.320	11.316	11.552	11.548
Shibata	11.281	11.283	11.520	11.521
Hannan-Quinn	11.295	11.295	11.531	11.530
Log- Likelihood	-22048	-22053	-22518	-22523
No. Obs	3913	3913	3913	3913

Utilities

Four Specifications of the DCC model

	DCC	DCC	DCC	DCC
AR(1)	Yes	No	Yes	No
Distribution	MVT	MVT	MVNORM	MVNORM
Akaike	11.042	11.043	11.333	11.775
Bayes	11.081	11.077	11.365	11.802
Shibata	11.042	11.043	11.333	11.775
Hannan-Quinn	11.056	11.055	11.345	11.785
Log- Likelihood	-21581	-21584	-22154	-23021
No. Obs	3913	3913	3913	3913