CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

The COVID-19 Impact on Oil Market and Equity Market Link: An Evidence from ARMA-GJR GARCH-M Model

by

Abbas Haider

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I want to dedicate this thesis to my parents, respected teachers and friends for their love, support and care.

CERTIFICATE OF APPROVAL

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(Abbas Haider)

Abstract

The main objective of the study is to explore the COVID-19 impact on the bidirectional spillover between WTI and six developed and six emerging equity markets by using daily data from January 1, 2010 till October 9, 2020. ARMA GJR-GARCH-M model is used to study mean and volatility spillover, asymmetric behavior and forecasted volatility. The findings of the study shows bidirectional mean spillover between oil market and equity market except Pakistan equity market. Similarly bidirectional volatility spillover is found except China and Japan because they have unidirectional relationship with oil market i.e. from China to WTI and from WTI to Japan equity market. The returns of COVID period are different in case of WTI, U.K., Germany, U.S., and France while volatility of COVID period is different in case of WTI, Germany and Italy equity markets. Moreover the results reveal positive significant spillover from equity markets of Pakistan, India, Brazil, South Africa, Germany, Italy and France to the oil market WTI during the COVID-19 pandemic which indicates that returns spillover is high during the crisis period while in reverse direction mean spillover from oil market to all equity markets except Brazil is high during the COVID period. Furthermore the results provide evidence of the bidirectional volatility spillover between crude oil market WTI and developed emerging markets during the COVID-19 pandemic. Only Japan equity market has unidirectional relationship with WTI which confirms that high volatility in Japan equity market due to COVID has a direct effect on the volatility of oil market. Moreover the Japan equity market is not influenced by the high COVID volatility in WTI. This study is helpful for portfolio managers, speculators, investors, policy makers and risk managers in diversifying portfolios of most affected countries by COVID-19 pandemic and also beneficial in risk management.

Keywords: Returns Spillover, Volatility Spillover, COVID Period Spillover, Developed and Emerging markets, Crude Oil Market WTI, ARMA-GJR-GARCH (1, 1)-M

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Abbreviations

ARMA-GARCH	Autoregressive Moving Average GARCH
COVID-19	Corona Virus Disease of 2019
DCC-GARCH	Dynamic Conditional Correlations GARCH
EMH	Efficient Market Hypothesis
EVD	Ebola Virus Disease
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GARCH-M	Generalized Autoregressive Conditional Heteroscedasticity in Mean
GJR-GARCH	Glosten-Jagannathan-Runkle GARCH
MERS	Middle East Respiratory Syndrome
SARS	Severe Acute Respiratory Syndrome
S&P500	Standard and Poor 500 Index
VAR GARCH	Vector Autoregressive GARCH
WHO	World Health Organization
WTI	Western Texas Intermediate

Chapter 1

Introduction

In recent times a deadly virus was recognized at the city of Wuhan, China. The virus was believed to be transmitted through air droplets from one affected human to another which can cause high mortality rates at a specific region. The first case was reported on 31st December 2019. The spread of deadly virus was so rapid that it affected almost 221 countries across the globe. On 11th February 2020, the virus was named as COVID-19 which stands for Coronavirus Disease of 2019. WHO announced it as a Public Health International Emergency officially on 30th January 2020 and in the span of 42 days the WHO announced it as a global pandemic on 11th March, 2020. The total number of confirmed affected cases touches a line of 94.43 million and total deaths were 2 million as of January 16, 2021. According to Liu et al. (2020) the most affected countries were U.S., Italy and China that has confirmed the most number of COVID cases at the early days of pandemic.

China recovered within three months due to strict lockdown and extensive macroeconomic policies but after China, the virus center shifted gradually to the United States and then to Europe. A study by He et al. (2020) revealed that countries with the largest number of confirmed cases in the world include China, Italy, South Korea, France, Spain, Germany, Japan and the United States of America. The BRICS countries recorded the high number of confirmed cases very soon after the outbreak. Equity returns of these markets were more sensitive because their governments also imposed lockdown and other strict measures. According to

the Organization for Economic Cooperation Council, the economic consequences of the COVID-19 pandemic were bigger than the financial crisis of 2007-2009 (Öztürk et al., 2020).

It has been obvious that the pandemics create fear in the market and that fear triggers in the activity of buying and selling. Due to globalization all the equity markets are interconnected with each other. So fear caused by the pandemic in one market has an effect on other market as well. International crude oil market has also been the center of attention and is linked with both emerging and developed equity markets of the world. So fluctuation in crude oil market has consequences on equity markets. This relationship is bidirectional. Fluctuations that are caused by the pandemic in equity market are transferred to the crude oil market and abnormal movement in the oil market has certain repercussions on equity market as well.

Recently the novel coronavirus COVID-19 has put the whole world into lock-down due to which all the business activity around the world came into the halt. The global investors have faced huge losses in the financial markets. The oil market prices have also gone down to an abnormal level in the history because of decreasing demand and high fluctuation in prices due to the COVID-19 pandemic. It indicates that variation in the oil market have a direct effect on the developed and emerging equity market and similarly fluctuation in equity markets result in the decreasing demand for oil which in turns decreases the stock prices of the oil market.

The health crisis emerged in the world by the COVID-19 pandemic put the performance of financial markets to an abnormal level. The emerging markets and well developed markets faced big shocks. According to Salisu and Akanni (2020) the well-developed equity markets were affected by the COVID-19 pandemic with the United States equity market declining by 32%, Italy stock market by 39.3% and U.K. stock market by 27.9%. Similarly the emerging markets were also the worst hit with the Brazil equity market fell by 40.5%, Chinese financial market by 10.1% and Russia by 24.2%. A cumulative loss by the financial markets between January and May were about 9 trillion US dollar and the global stock markets lost

its value by 12.35% as a whole. Shehzad, Xiaoxing, Arif and Rehman (2020) found that the Spain financial market was declined by 27.3 percent due to the COVID-19 pandemic. Poland, Belgium, Thailand, South Africa, Argentina, Austria, Norway, Greece and Colombia registered their highest one day fall with the values of 38%, 39%, 39%, 40%, 40%, 47%, 44%, 42% and 41% (GÖKER et al., 2020).

During the COVID-19 pandemic, March 09, 2020 was the day when the Saudi Arabia started an oil price war and flooded the market with a huge amount of oil due to which the oil prices went down to approximately 20% in a single day. So the high volatility in crude oil prices followed by the worst stock market crashes in history during the same day (Albulescu, 2020). The oil market prices reduced due to decrease in demand of oil worldwide because strict lockdown was imposed throughout due to which the transportation and tourism sector were also at a situation of halt. The drastic low demand cut the crude oil prices from 61$ to 12$ in the international market (Prabheesh et al., 2020). When the social distancing measures and travel restriction were implemented, the Western Texas Intermediate (WTI) has registered a record maximum loss of 60% in a single day. When the demand for oil decreased due to COVID-19, the oil prices fluctuated regularly with record low stock prices in history. So both the oil market and equity market were severely affected by the COVID-19 pandemic.

The flow of goods and services were massively disrupted due to sudden measures taken by respective government i.e. social distancing, travel restriction and lockdown. The well-developed countries such as Italy, France, Germany, U.S., U.K., and Japan were adversely affected by these sudden measures along with the emerging BRICS countries. More precisely the financial markets of these countries received several global economic and financial shockwaves (Harjoto et al., 2020). Especially the Russian economy was severely affected, as a consequence of the oil price war triggered together with the outbreak of the COVID-19.

In order to find the solution for recovery the objective of the China was to flatten the curve of COVID-19 in order to resume the economic activity. According to the financial cycle view, extraordinary macroeconomic decisions were required to mitigate the economic meltdown (Liu et al., 2020). The well developed and

emerging countries also took extensive precautionary measures to stop the turmoil in financial markets. Most of them planned to spend and lend trillions of dollars to protect their economies against disruptions because COVID-19 disturbed the activity of buying and selling. Alternative measures to put the performance of financial markets on track was monetary easing by governments, zero interest rate policy to small and medium enterprises etc. The COVID-19 outbreak had bad consequences on well-developed and emerging economies, the extensive policy measures helped out in reviving these economies because if the markets react to the bad news of COVID-19 uncertainty, the extraordinary macroeconomic policies also played a positive important role in mitigating risks related to financial markets in the light of the famous efficient market hypothesis (EMH) theory.

1.1 Theoretical Background

1.1.1 Efficient Market Hypothesis (EMH)

Stock markets around the world are reactive to global pandemics. According to Efficient Market Hypothesis theory stock markets respond to the arrival of new information either it is good news or bad news. In both cases the equity market cash flows result in positive returns or negative returns depending upon the consequences of that new information. According to a study by Hasan and Javed (2009) equity market returns are considered to be the most important economic indicators to represent a country economically. The returns of financial markets are reactive to new information and in pandemics like SARS, COVID-19, etc. the impact on financial markets is stronger. Due to globalization stock markets all over the world are interconnected with each other. Due to the high depth of the financial market fluctuations in them can clearly be observed.

According to Malkiel (1989) the idea of Efficient market hypothesis theory is connected with the random walk which means that the flow of information is unpredictable and that is reflected in the stock prices of financial markets. Prices fluctuate due to the uncertainty of new information in the market.

The new information may be in the form of pandemic, global war, financial crisis etc. Well integrated financial markets are the result of quick information transmission from one market to another. The cash flows in equity market fluctuate on the announcement of new global event. When stock prices fluctuate in one market, it has consequences on other equity markets as well. The Efficient market hypothesis theory has gained much attention in the nexus between stock market cash flows and new information arrival. Financial markets are efficient if they respond on the arrival of new information like COVID-19 announcement. The uncertainties in financial markets continue to increase due to COVID pandemic due to which the stocks of certain financial markets are plunged.

Responding to situation, the zero interest rate policy and unlimited quantitative easing by the Federal Reserve are the best tools to mitigate the uncertainty of financial markets. So these macroeconomic policies by the authorities have reduced the uncertainty in the financial markets but as the pandemic continue to grow, the uncertainty still remain in the equity markets (Zhang et al., 2020). So policy intervention also has a great role to make the cash flows of financial markets stable. If the stock prices are fluctuated by the COVID news, they can revive by the government economic policies. The extraordinary macroeconomic policies are priced by the financial markets and they perform well even in the pandemic situation. If the stock prices did not adjust to the new economic policies or global pandemics, then it means that there is inefficiency in the market.

Financial markets and crude oil market have a great link with each other. In order to mitigate the risks associated with the COVID-19, certain measures are taken by the well developed and emerging countries. Countries affected by the pandemic went into lockdown policy while some went into the smart lockdown policy, travel restrictions and strict quarantine policies but it has greatly influenced the economic condition of COVID affected countries. Some applications of efficient market hypothesis are studied by various researchers in the light of COVID-19 pandemic. The financial markets and oil market have responded extraordinarily to the news of COVID-19 pandemic. The stock prices of crude oil markets are declined to a record 60% in history due to a record low consumption.

Low consumption is due to the strict lockdown policy and travel restrictions. In March 2020 the global stock markets have witnessed the most dramatic crashes in the history (Mazur et al., 2021).

According to Nhamo et al. (2020), the COVID-19 pandemic has put the world into economic crisis so rapidly that the world has not witnessed in over a century. They used event study analysis to find the impact of COVID-19 on tourism stocks because their share prices decline up to 80% on global stock markets within a two week period. This decline mean the lockdown policy is priced by the tourism industry. In context of Pakistan equity market, the smart lockdown has a positive effect and the stock market performance is not much affected as compared to other countries. So the smart lockdown policy has positive implications to the Pakistan economy.

According to Ashraf (2020), the strict policies implemented by the authorities help in reducing the spread of disease but it has certain consequences on the financial markets by decreasing the effectiveness level of equity markets and increasing the uncertainty. According to Albulescu (2020), the stock markets recorded several shock waves starting with February 2020, whereas the financial volatility continues to increase in the context of COVID-19 uncertainty which is another application of efficient market hypothesis (EMH) theory. It means the stock prices respond to the increasing number of COVID cases in the respective countries.

1.2 Gap Analysis

A lot of studies have been done on economic integration especially during the unfortunate situation of financial crisis, global pandemics and other global economic events. The international financial markets such as the United States, the United Kingdom, Japan, Australia and India have been analyzed in the context of returns spillover and volatility spillover by applying GARCH model (Sakthivel et al. (2012); Pan and Hsueh (1998)). Similarly the London equity market, New York equity market and Tokyo financial market are explored in case of asymmetry by using EGARCH model (Koutmos and Booth, 1995). Some stock returns are

studied through the phase of the post-financial crisis and pre-financial crisis in 1997 (In et al., 2001).

The oil prices volatility in connection with the equity market volatility is explored by a variety of studies through EGARCH model and GJR GARCH model (Ashfaq et al. (2019); Abdelhedi and Boujelbène-Abbes (2019); Boubaker and Raza (2017)). Recently some studies employ event study analysis to find the impact of COVID-19 on world markets (AlAli (2020); Maneenop and Kotcharin (2020)). On the announcement of COVID-19 as pandemic by World Health Organization, the oil prices decline to an abnormal level and it creates an impact on stock markets across the globe. So the oil stock nexus is of great importance in the context of COVID-19. Especially the well-developed equity markets and emerging markets in connection with the crude oil market (WTI) need to be explored during the COVID-19 pandemic in the context of mean and volatility spillover.

The oil stock nexus is studied by Shehzad et al. (2020) in case of some worst hit developed countries like U.S., U.K., Spain, Italy and Germany by using co-integration analysis technique and NARDL approach. Similarly other historic diseases like SARS, MERS, Spanish flu are studied in connection with financial markets and tourism stocks (Burdekin (2020); Chong et al. (2010)). The standard deviation approach, simple regression approach and event study methodology are used for exploring the impact of these diseases on stock prices. The impact of diseases on financial markets and world economy is explored very little in the context of spillover especially during the COVID-19 pandemic.

During COVID period we observe the fall in the equity markets and oil markets respectively. The impact of COVID-19 on oil prices are reflected in equity returns through the expectation of decrease in demand of oil. Due to COVID-19, the lockdown has affected the sentiments of investors and that behavior has an impact on the prices of equity market. So there is a need to find the impact of COVID-19 on developed and emerging equity markets and crude oil market through the spillover from equity market to the oil market and spillover from the oil market to stock market. This study fills the gap of economic integration during the COVID outbreak in case of some developed and emerging equity markets and crude oil

market (WTI). This study examine the shock created from oil market to stock markets and then investigate the shock created from stock market to oil market during the COVID outbreak.

1.3 Problem Statement

Investors are hesitant about investing in equity markets due to the COVID-19 pandemic. The economic activity has decreased due to the spread of coronavirus. People are not participating in the investment activities because of the lockdown policy. Due to the pandemic, there is another issue of portfolio diversification. Also there is an impact of COVID-19 on oil market because economic activities have decreased, roads are blocked and aviation industry is stagnant. This study provides the international investors an insight to invest in those stock markets which are less affected by the pandemic. It is the need to find that during the COVID period shocks from the oil market influence stock market or not. Also this research provides an insight that do changes in prices of equity markets affect the oil market during COVID-19 period.

1.4 Research Questions

On the basis of the research gap, following question are raised:

Research Question 1

Do returns of the oil market influence equity market?

Research Question 2

Do returns of the equity market influence oil market?

Research Question 3

Does mean spillover from oil market to equity market high during the COVID outbreak?

Research Question 4

Does mean spillover from equity market to oil market high during the COVID outbreak?

Research Question 5

Does volatility spillover exist from the oil market to equity market?

Research Question 6

Does volatility spillover exist from equity market to the oil market?

Research Question 7

Does volatility spillover from oil market to equity market high during COVID-19 period?

Research Question 8

Does volatility spillover from equity market to oil market high during COVID-19 period?

1.5 Objectives of the Study

Research Objective 1

To examine mean spillover from equity markets to oil market and vice versa.

Research Objective 2

To provide an insight about mean spillover from equity market to oil market during COVID-19 period and vice versa.

Research Objective 3

To investigate volatility Spillover from equity markets to oil market and vice versa.

Research Objective 4

To provide an insight about volatility spillover from equity market to oil market during COVID-19 period and vice versa.

1.6 Significance of the Study

As we know that due to globalization, all markets are interconnected with each other. Those investors who want to make their investments globally have the risk

due to the COVID-19 pandemic. Overseas investors need an insight about mean and volatility spillover during the COVID-19 period so that they can invest in those equity markets which are less affected by the global COVID-19 pandemic. Moreover, they can also plan for portfolio diversification to divide their risk in those stock markets which are less affected by the COVID-19 pandemic. Investors may also come to know about the volatility of oil market through shocks of financial markets.

The equity markets are the early indicators so the economic activity of future period can be predicted by looking at the cash flows of the equity market. When prices decline in the equity market due to pandemic, it gives the indication that future period economic activity will be reduced due to which the requirement of oil market will also be reduced. So we can say equity markets are the early indicators for the reduction in the demand of oil. Hence the oil market demand can be predicted by looking at the cash flows of financial markets.

1.7 Plan of Study

Chapter 1 covers the Introduction, Theoretical Background, Gap Analysis, Research Questions, Problem Statement and Objectives and at the end Significance of the Study. Chapter 2 includes the literature review regarding past studies in context of two way spillover between crude oil market and financial markets, worlds leading markets reaction to various pandemics and hypothesis of the study. Various methodologies are employed in the study that is covered in chapter 3. Data Analysis and interpretation are briefly discussed in chapter 4. In last, conclusion, recommendations, limitation and future directions of the study are covered in chapter 5.

Chapter 2

Literature Review

There are various empirical studies that describe the dependency of equity market on the WTI oil market and vice versa. The literature review of this section is categorized into two parts. In the first part the worlds leading markets reaction to the pessimism of historic pandemics are discussed. The second section explores the mean and volatility spillover from oil market to equity market and similarly from equity market to oil market.

2.1 Worlds Leading Markets Reaction to the Pessimism of Pandemics

The world has experienced with a number of historic pandemics. Some of the most popular ones in the literature are SARS, MERS, Swine flu, Spanish flue, EBOLA virus and Bird flu etc. Recently the world is experiencing with a new pandemic called the COVID-19 pandemic which has hit the world markets very badly. The literature has discussed the impact of pandemics on world markets by using event study approach, standard deviation approach, panel regression analysis, simple regression analysis, VAR based approach etc.

The very first virus outbreak of 21st century is the Severe Acute Respiratory Syndrome (SARS) which emerged in the China in the last quarter of 2002 and it has spread to almost 29 countries with the more than 8000 cases and 813 deaths.

The economies of most affected countries were affected severely by unfortunate situation of SARS pandemic. The Hong Kong economy was collapsed by the unexpected decrease in demand of local consumer products and export of services (Siu and Wong, 2004). According to a study by Nippani and Washer (2004) the SARS outbreak had a negative impact on the equity returns of China and Vietnam. Thailand, Canada, Indonesia, Singapore and the Philippines economies were less affected by the outbreak. Daily data is used on the basis of two periods i.e. pre-SARS period and SARS period. The non-parametric Mann-Whitney test and event study was used to test the significance between SARS outbreak and equity returns of affected countries.

Events study analysis by Chong et al. (2010) provided that there was a great impact of SARS on the Chinese economy. Meanwhile the tourism and pharmaceutical industry are one of the two main pillars of Chinese economy so the stock returns of tourism industry and pharmaceutical industry were used for the analysis with respect to the SARS outbreak. The event window was taken 42 days before and after April 21, 2003. The abnormal returns of tourism industry was found insignificant while pharmaceutical industry results were significant which proved that tourism industry performance is dropped dramatically and pharmaceutical industry performance was best in the business after the SARS outbreak. The impact of SARS outbreak on global economy was explored by Lee and McKibbin (2004) by using Asia-Pacific G-cubed model. The daily data was used on the basis of first case reported in Asia-Pacific belt during the year 2003. The study of their results explored that China and Hong Kong economies were at the receiving end of SARS outbreak because of fixed exchange rate regime which in turn increased the costs of SARS outbreak. Another important thing to note was that the economic downfall of one country has an effect on the economy another country as well due to globalization and integration of financial markets.

The Taiwan economy during the SARS outbreak was adversely affected because of the decreasing number of tourists and visitors. Yang and Chen (2009) explored the connection between the number of inbound visitors and their consumption expenditure on the economy of Taiwan. A general equilibrium model and social

accounting matrix was used for the analysis. The social consumption expenditure data of year 2001 was used. They identified that GDP and employment was affected by the decreasing number of tourists during the pandemic. Another study by Lee and Warner (2006) focused on the service sector of Singapore during the SARS pandemic. They used a two-pronged methodology by collecting information about the SARS outbreak through certain sources and secondly they do on-site research by taking interviews of representatives of the Singapore economy. The consumer demand, service sector, and labor demand in Singapore hotel industry were negatively affected due to the unfortunate situation of SARS outbreak in the Singapore economy.

Chou et al. (2004) by using multiregional computable general equilibrium model to test the significance of SARS outbreak on the basis of short term shocks to the service sector and manufacturing sector of Taiwan. 31 sectors and 16 regions were used for the analysis. Results indicated that Taiwan was moderately affected by the SARS epidemic as compared to mainland China, Hong Kong because of the huge decline in tourism industry. The Taiwan hotel industry stocks were analyzed by Chen et al. (2007) through an event study methodology. Negative cumulative abnormal returns were recorded due to the unforeseen situation of the SARS pandemic. So the hotel stocks of Taiwan were significantly related to the SARS announcement.

A co-integration analysis technique was used to analyze the co-movement relationship between Asian countries indices during SARS outbreak and before SARS epidemic. Daily data of equity markets of China, Hong Kong, Singapore, Taiwan, Philippines, Indonesia and Thailand were used covering the period January 1, 2001 to February 25, 2003 as pre crisis period and February 26, 2003 to December 31, 2004 as SARS period. The Vector Error Correction model indicates the increase of co-integrating relationship between China and other Southeast Asian markets during the epidemic. So the SARS outbreak had made the Asian financial markets much more closer to each other during the unfortunate situation of pandemic (Bhuyan et al., 2010). The same methodology approach was used by David et al. (2021) on the stock prices data of well developed economies like U.S.,

Japan, Germany, France, Italy and India. The abnormal movement caused by the pandemics like SARS, MERS, and Ebola etc. was transferred to these financial markets. Vector Error Correction model was used to describe the co-movement between stock market and disease outbreak. First 79 days of infected cases of four diseases were used for the analysis. The results suggested that higher the number of cases, the higher will be the decline in cash flows of the financial markets.

Chen et al. (2018) explored the long term co-movement strength between China and four Asian market (Singapore, Taiwan and Hong Kong) during the SARS outbreak by using the weekly data of stock indices covering the period 1998 to 2008 i.e. five year before SARS outbreak and five years after SARS outbreak. Time varying co-integration analysis technique was used to test whether the pandemic has strengthen the long term co-integrating relationship between China and other Asian stock markets. The finding of their study revealed that the long term integrated relationship between these financial markets did weaken due to the pandemic. The study concluded the heterogeneity in the stock markets which was a good opportunity for investors to diversify their portfolios.

The tourism industry and the global pandemics had a very close relationship with each other as experienced in the past. Each time when a health crisis emerges, it had consequences on the stocks of tourism in the affected country. The Middle East Respiratory Syndrome MERS was another disease that emerged in Saudi Arabia in 2012 and transmitted to other Middle Eastern countries and several other countries were also infected. The travel restrictions severely affected the economy of countries having well developed health system. Another outbreak of MERS was recently in May 20, 2015 in the Republic of Korea when traveler from Middle East caused the spread of virus in Korea.

Joo et al. (2019) extensively investigated the impact of MERS on the economy of Republic of Korea by analyzing the stocks of tourism-related sectors i.e. hoteling, food consumption etc. Seasonal autoregressive moving average model was used on the monthly data of number of tourists arrival and indices of three tourism related sectors covering the period June, 2015 to June, 2016. The finding explored that 2.1 million noncitizen arrivals were negatively correlated with the MERS

outbreak. During the extreme situation of pandemics, the travel-based economies were affected.

About a decade ago a same disease like SARS, MERS and COVID-19 which widely referred to as Spanish Flu began in March 1918 during the end of World War I and caused the death of over 50 million worldwide. The second wave was more fatal from September to November 1918 and even many nations experienced a third in the early 1919 (Patterson and Pyle, 1991). Burdekin (2020) find the impact of Spanish flu on stock markets of U.S. and European countries. He compared death rates with stock markets returns by using panel regression analysis and finds that stock markets reacted significantly and negatively during the Spanish flu. Karlsson et al. (2014) investigate the impact of deadliest Spanish flue on the economy of Sweden. An extension of difference in difference methodology approach was used to test the impact of pandemic on Swedish economy. The findings of their study concluded that pandemic had a negative relationship with the capital incomes of Sweden. The response to shocks was somehow immediate and somehow moderate.

Another infectious disease that announced by the WHO recently in March 23, 2014 was the Ebola virus disease (EVD). The first case of EVD was reported in Southeastern Guinea. By the time total 49 cases and 39 deaths were reported. The virus was believed to be transmitted from an affected animal to humans (Sifolo et al., 2015). It was further believed that human to human transmission occurs via direct contact with blood or bodily fluids from an infected person When EVD news disseminated in the market, it created a great impact on the financial markets. According to an event study performed by Ichev and Marinč (2018) there was significant impact of the virus on the stock returns of U.S. and Western Africa. The study used one factor model and two factor model regression based analysis for the 2014-2016 Ebola outbreak. Their findings suggested that events like Ebola outbreak were followed by the negative returns in the financial markets. Similarly the Ebola virus had an impact on the tourism industry as well and tourism has a great deal with economic growth of a country. A study by Sifolo et al. (2015) found that Ebola has hugely affected the tourism sector of Tanzania. They used a multi-sectorial approach to find a solution for the tourism industry.

The public health emergency worldwide due to the novel coronavirus also had a direct and indirect effect on the economy of the well-developed countries and emerging countries. The COVID-19 pandemic is also crucial to the relationship between oil market and stock market. A comprehensive analysis was done on the oil-stock nexus during the COVID-19 pandemic by Salisu and Akanni (2020) in which they found the response of oil market and stock market through shocks of COVID-19 pandemic. The study used panel VAR (Vector Autoregressive) model by using daily data of stock prices of France, Mexico, US, UK, Brazil, China, Belgium, Canada, India, Germany, Netherlands, Russia, Spain, Turkey and Brent oil prices. The data used in the analysis was divided into two phases i.e. Pre-COVID period and Post-COVID period. The period before COVID starts from January 4, 2019 to March 10, 2020. The period after COVID announcement starts from March 11, 2020 to May 29. 2020. The results of Granger causality indicated unidirectional causality from oil to stock during pre-COVID period while it was bidirectional from oil to stock after COVID announcement.

Similarly impulse response function also showed negative stock returns during the period of panic and uncertainty. So the need for financial markets to perform efficiently in the COVID pandemic was well organized fiscal and monetary policies by the policy makers and by making strong policy decisions to handle the inconsistencies in the cash flows of stock market and oil market. Prabheesh et al. (2020) by using DCC-GARCH model examined the time varying conditional correlation between crude oil market and four major oil importing Asian countries i.e. China, India, Japan and Korea during the month of February, March, April and May 2020. The sample period was covering the period from January 1, 2020 to June 8, 2020. The month of March particularly strengthened the relationship between oil market and all four stock markets which mean the hype created in the market by the COVID-19 were priced by the financial markets and oil market. Moreover their study revealed that there exist positive co-movement between net oil importing countries and the crude oil market during the era of COVID-19 pandemic.

Another study by Sherif (2020) used panel data analysis testing for UK Dow Jones sharia compliant index, conventional index UK (FTSE100) and 10 other

UK based sectorial indices. Daily data of stock returns are used from the period 20th January, 2020 to 20th May 2020. The study also used the daily COVID tally of UK. Islamic Dow index appeared to be less exposed to the COVID-19 pandemic as compared to its counterpart FTSE100 index. Sectorial based analysis provided that IT sector performed extremely well during the pandemic while consumer based sector performance was non satisfactory. The study provided the insight to investors about the faith based index that are less risky as compared to conventional index during the extreme time of COVID-19 pandemic. Conventional equity market indices that are more exposed to risk will be restructured by financial reforms, trade and revised economic decisions. The same methodology of panel data analysis technique is being used by Ashraf (2020) in which he used the daily data of most affected financial markets from 64 countries during the period 22nd January, 2020 to 17th April, 2020. His findings explained that with the growing number of affected cases, the returns of equity market responded negatively as compared to the growing number of deaths confirmed due to COVID pandemic.

The epicenter of the COVID-19 was shifted gradually from China to the rest of the globe which has put the financial markets in the state of decline around the world and in the phase of more and more spread, the equity markets were more at stake. The top nine most affected countries i.e. China, US, UK, Germany, France, Spain, Switzerland, South Korea and Italy were studied by taking their MSCI indices through the process of exponential GARCH (EGARCH). The sample period is taken from January 1, 2020 till March 20, 2020. Three phases of the casualties are used for the analysis. When casualties increased in china, the US market was less volatile in 1st phase. In the second phase when the number of casualties started increasing in Europe, the American financial market volatility was more influenced. In the third phase when casualties numbers started to increase in the US, the China equity market was revived at that time and same is the case with European markets. The reason is the epicenter shifting from China to Europe and then to United States. In the third phase when the epidemic has now become a pandemic, the US market volatility was at extreme. The increasing death ratio has a significantly direct relationship with the volatility of financial markets (Ali

et al., 2020).

Major oil and gas producers in the U.S. were also affected by the COVID emergency. Iyke (2020) analyzed the stocks of about 90 US oil and gas producers and the COVID-19 daily data of total deaths per million (TDM) by using the ARCH-GARCH model. Sample period was from January 21, 2020 to May 5, 2020. The study examined the impact of COVID-19 pandemic on returns of oil and gas but heterogeneously because the oil stock and gas stock respond differently to the pandemic. Similarly the COVID-19 had statistically significant relationship with the volatility of stock returns. The different reaction by oil and gas firms was due to the size and turnover rate of these firms.

Lahmiri and Bekiros (2020) study the effect of pandemic on the volatility of WTI, Brent, Gas, Gold, Silver, Bitcoin and S&P500. GARCH model was used to estimate the volatility. The daily closing prices of seven world major markets were used for the period August 01, 2019 to December 31, 2019 as a pre-pandemic period and the COVID period was taken from January 2, 2020 to May 26, 2020. The empirical results provided that S&P500 index volatility and precious metals volatility were affected the most by the pandemic as compared to oil and gas markets volatility. The equity index of S&P500 was found more volatile due to COVID as compared to other markets. More precisely the WTI was more volatile than Brent because of Russia-Saudi Arab oil price war in 2020. The Bitcoin also represent the same volatility as the S&P500 index volatility as they were interconnected.

The financial distress faced by the investors around the world by the COVID-19 pandemic was the major area of concern. The affected cases ratio, death ratio by the COVID-19 was analyzed with financial market volatility index by using the simple regression analysis. Albulescu (2020) detect that as the new cases ratio increased, the financial volatility was also increased. Death ratio had a significantly positive impact on the financial market volatility. Huang and Zheng (2020) explored the relationship between the investor sentiment and crude oil prices during the COVID-19 pandemic by using Engle and Granger co-integration method. Crude oil market volatility index was used as a proxy for investor sentiment and

WTI prices was used as a proxy for crude oil market. Daily data was used for the analysis covering the period from January 2, 2020 to May 11, 2020. The finding of their study suggested that there were two structural breaks due to COVID-19. They found that there exist statistically significant relationship between the investor sentiment and crude oil market. The second structural change was found to be much stronger than the first structural change. In extreme times like the COVID-19 era, the oil market volatility is strongly influenced by the investor behavior (Wang et al., 2020).

The Asian market volatility has also been taken into consideration by Sharma (2020) during the COVID-19 pandemic. He used the daily data of five developed economies i.e. Japan, Singapore, South Korea, Hong Kong and Russia covering the period from January 1, 2000 to September 25, 2020. The ARCH-GARCH model is used for the volatility commonality between these economies. The country level volatility of Japan, Singapore and South Korea are influenced by the COVID-19 pandemic while the other two economies were not influenced by the COVID outbreak.

The GARCH in mean model was used to study the relationship between Japanese Yen and Japanese stock market during the COVID-19 pandemic. The strength of relationship between exchange rate and stock returns was high during the pandemic as compared to pre-COVID period. The standard deviation was 25% at pre-COVID period and then it was shifted to 71% during the era of COVID-19. Pre-COVID data was taken from the period January 04, 2019 till December 30, 2019 while the COVID-19 sample was taken from the period December 31, 2019 till August 17, 2020. The depreciation of the Japanese currency was due to the decline in the stock returns of Japan financial market (Narayan et al., 2020).

Appearing the very first in China, the COVID-19 pandemic had a high impact on the Chinese insurance market. Monthly provincial data was taken for the first quarter of year 2018, 2019, 2020 based on the famous quote in Chinese insurance market that a good start means a full success in the year. Fixed effect model was used in the panel data analysis. The data of 29 provinces was analyzed. The results showed that as the number of cases increased, the growth rate of insurance

premium reduced and gross premiums as well. The property insurance premium was affected badly by the pandemic as compared to personal insurance premium (Wang et al., 2020).

Mishra et al. (2020) investigated the pandemic fear on India financial market as compared to recently two major structural changes of Indian economy i.e. demonetization and goods and services taxes. Exchange rates data, net foreign institutional investment data and stock returns data was used on daily basis from the period 3rd January, 2020 to 30th April, 2020. Markov-Switching VAR nonlinear dynamic model was used to determine the impact of COVID fear on financial market of India. Negative growth, negative stock returns and higher volatility were the key results during the COVID pandemic unlike the era of demonetization and GST. So there was a severe impact on Indian stock market returns during the pandemic.

Using the panel data regression models, Anh and Gan (2020) examined the effects of pre lockdown and lockdown on the equity returns of Vietnam stock market which is considered to be an emerging market in modern era. Daily data of stock returns were used from the period January 30, 2020 to May 30, 2020. The results of their study revealed a significant negative impact on the equity returns of Vietnam during pre-lockdown while during lockdown there was a significant positive impact on the equity performance of the Vietnam financial market. The Vietnam economy revived itself very soon after the lockdown because of its favorable equity prices and the best government decisions. So by making better macroeconomic policies, it gives a boost to investor confidence which in turn increases the economic activity in the country.

The novel coronavirus had suffered the human life a lot. In case of Turkish financial market (BIST) at the sectorial level, the empirical research was done by Öztürk et al. (2020) in which they used the panel data analysis. Fixed effect model was applied on the data Turkish metal products, machinery, insurance, banking sectors, sports, wholesale trade, retail trade, real estate and food beverages covering the period from January 2, 2020 to April 15, 2020. Volatility index, number of coronavirus confirmed cases, sectorial stock indices and Turkey daily default credit

swap were used for the analysis. The empirical results showed that stock indices returns of sectorial industry were affected by the increasing number of COVID cases. Although food sector, wholesale and retail sector were affected less by the pandemic as compared to other sectors. The attitude of investors toward other most affected sectors will change with the passage of time as the news related to COVID treatment and support measures by the government become more concise and clear.

The 26 sectorial based stocks of Borsa Istanbul Financial market returns were examined by an event study organized by GÖKER et al. (2020) in which they examined the negative cumulative average abnormal returns in most sectors. Moreover in their study they examined that tourism industry, sport industry and transportation industry were the worst hit by the COVID-19 pandemic. Similarly the Standard and poors index (S&P-100) were used to analyze the 1500 firms of the United States during the month of March 2020. The worst collapse by the stock prices in the history was studied through event study analysis. Quite surprisingly some stocks i.e. food sector, health sector, natural gas sector and software sector performed abnormally well under the COVID-19 pandemic while the entertainment industry, hospitality sector, real estate industry and petroleum industry stock were dropped highly (Mazur et al., 2021).

An event study analysis was used to determine the impact of the COVID announcement by WHO on the stock returns of China, Japan, India, Hong Kong and South Korea by using the daily data from the period March 04, 2019 till April 22, 2020. The mean adjusted model and market adjusted model showed negative returns after the announcement of COVID as compared to pre-COVID period. Abnormal returns and cumulative abnormal returns were recorded negative for these countries after the COVID-19 pandemic. It confirmed that Asian equity markets were responded to the announcement of the COVID pandemic (Ali et al., 2020). Similarly Liu et al. (2020) investigated the impact of COVID emergency on the daily stock prices of 21 most affected countries which include Australia, Italy, Japan, France, US etc. The study employed the data of stock market returns covering the period February 21, 2019 till March 18, 2020. The finding of

the event study methodology revealed a significantly negative relationship between the COVID emergency and all the stock returns. Furthermore the Asian markets were much closer at the receiving end for the COVID emergency.

The event study methodology was also used for the pessimistic situation of COVID on the worlds leading 52 listed airline industries. When the first case was reported outside China and the announcement of WHO to declare the outbreak as a pandemic had a significant impact on the returns of airline industry. The overreaction by the pandemic news and global travel ban had put the stocks of airline industry into a free-fall and especially the stocks in Australia, Canada, the U.S., and U.K. were the worst performers (Maneenop and Kotcharin, 2020). The China and U.S. equity markets were most hit by the pandemic in the start. Susan (2020) analyzed the relationship between the equity returns of US and China with number of confirmed affected cases of COVID-19 by using simple regression analysis. Daily of stock market returns were used for the period March 1, 2020 to March 25, 2020. The outcomes of his findings showed a positive and significant relationship between stock markets and confirmed coronavirus cases which means that the increasing number of affected number of COVID-19 cases had a direct influence on the stock returns of Shanghai index and Dow Jones index.

Pakistan stock returns performance was explored with daily positive cases, fatalities, and recoveries by using the daily data of PSX100 index returns during the first half of 2020 pandemic. Ahmed (2020) used simple regression analysis by taking the stock market prices of Pakistan as dependent variable and daily positive cases of Pakistan, recoveries and fatalities as independent variables. The results reported that equity market performance of Pakistan has a non-significant relationship with that of daily positive cases and mortality rates while there exist a significant positive relationship between recovery tactics and performance. So the stock performance was influenced by the recovery rates and other recovery tactics i.e. social distancing, economic relief etc.

The psychology of financial markets during the hard times of COVID-19 was explored by employing co-integration analysis and Non-linear Autoregressive Distributive Lag (NARDL) approach on the stock markets data of US, UK, Germany,

Spain and Italy during the period February 10, 2020 to April 09, 2020. Shehzad et al. (2020) findings revealed that there was an existence of long run co-integration in between economic crisis, health crisis and equity markets. The daily number of confirmed cases and mortality rates were also used for the study. The economic crisis and health crisis negatively influenced the US stock returns. In case of Spain the economic crisis by the COVID-19 pandemic had done more damage to the equity returns as compared to the health crisis while Italy had a different scenario in the long run. The stock returns of Italy were negatively influenced by the health crisis as compared to economic crisis. Moreover economic uncertainty caused by the COVID-19 pandemic was very high in case of German stock market which was followed by the US equity market and third in raking was Italy equity market.

Another ARDL approach was used by the Albulescu (2020) in which the new daily confirmed coronavirus cases were empirically examined with the crude oil prices (WTI) and financial market volatility index (CBOE). The time period used for the analysis was the early days of COVID-19 pandemic starting from January 21, 2020 to March 09, 2020. The existence of negative long run and short run co-movement was detected between financial volatility index, Crude oil market and new COVID cases. So the new confirmed cases blocked the world economy which in turn affected the crude oil market significantly.

Zeren and HIZARCI (2020) used the Maki co-integration analysis technique to test the significance between total daily cases reported and total deaths reported with the equity markets of most COVID affected countries i.e. China, Italy, France, Germany, Spain and South Korea. Daily data is used from January 23, 2020 till March 19, 2020. The finding of the study explored that there exist a long co-movement between total death and all the equity markets. China, Korea and Spain equity market were also found co-integrated with the total number of cases reported while Italy, France and Germany were not co-integrated with the total affected cases because of the extensive macroeconomic polies by European governments. It means that investors have the opportunity to invest in those financial markets that are less affected or not co-integrated with the COVID-19 pandemic.

Topcu and Gulal (2020) by using the Driscoll-Kraay estimator examined that there was a significant negative impact of COVID-19 pandemic on the emerging markets during the early days of March but in the month of April the result became insignificant. The sample period was taken in three sub periods i.e. 10th March to 31st March, 10th March to 10th April and 10th March to 17th April. The daily data of stock prices, exchange rates, oil prices and infection rates were used. In 26 emerging countries the highest impact was on Asian emerging markets and lowest impact on European emerging markets. The lowest impact was due to the extensive macroeconomic policies that were taken on time and stimulus economic packages by the governments of the respective countries.

The hype created by media outlets around the world was another source of high volatility in financial markets. Haroon and Rizvi (2020) have used the sentiment index, media coverage index related to COVID news and panic index (Ravenpack finance) by applying EGARCH model. The data set was comprised of Dow index, US index and world index that started from January 1, 2020 to April 30, 2020. They explored that the panic index had a direct relationship with the world index volatility. Negative sentiments (Global sentiment index) had an opposite influence on the US market volatility and media coverage had resulted in lower volatility in world markets. So in these circumstances investor prediction to assess the performance of equity markets is hard to examine because it is like a roller coaster for the decision makers and policy makers to make decision about their portfolio.

Government intervention was the most important aspect to cope with the economic crisis by the corona virus outbreak. Ashraf (2020) by deploying the pooled panel OLS regression model from the period 22nd January, 2020 to 17th April, 2020 with a sample size of 77 countries, had given the evidence of relationship between government response and equity returns. Three government response indexes were used to identify the nexus between the equity returns and government intervention i.e. strictness index (stringency index), health index and economic support index. They explored a direct negative and indirect positive relationship between stock market returns and strictness index which means the practice of social distancing was appeared to be crucial for stock market returns because of a

halt to the economic activity. On the other hand the same strictness index helped in reducing the number of coronavirus cases which later lead to positive stock market returns. Comprehensive health policies, testing and quarantine policies had a positive impact on the equity market returns. Economic support from the government i.e. income support packages, low or zero interest rate policy also had a positive impact on the returns of stock market. The phenomenon of social distancing and public awareness programs by the government were very productive in terms of financial markets performance.

The prediction of stock market returns is normally using the Chikago Board of Option Exchange (CBOE) Volatility index during any crisis in the world (Salisu et al., 2020). An important study was organized to use the Global Fear Index (GFI) for the prediction of stock market returns especially during the pandemic. In case of COVID-19 pandemic the Global Fear Index was used by adding the Reported Cases Index (RCI) and Reported Death Index (RDI). Panel data analysis was used to identify the Global Fear Index (GFI) as a good predictor of BRICS stock return during the pandemic (Salisu & Akanni, 2020). So the investors will better make decisions during the later stages of the pandemic. At the later stages they had got to the clear understanding the pandemic so prediction of stock returns were possible by using the Global Fear Index (GFI).

Policy interventions during the hard times of pandemic had an important role for the betterment of an economy. Zhang et al. (2020) identified the pandemic effect on the stock returns of well-developed equity markets i.e. Japan, Korea, Singapore and Iran. The patterns of standard deviation of financial markets were used from December 31, 2019 till March 27, 2020. Daily coronavirus infection cases were used in the analysis to study the risk factor of these financial markets. The patterns were clearly explored that there is an increase in the risk factor from February to March. The risk levels of all the countries have increased substantially, from an average of 0.0071 in February to 0.0196 in March. According to Gates (2020) the COVID-19 is behaving like once in a century pathogen due to which a much more profound impact on the world economy is expected. The risk factor can be minimized by the extraordinary macroeconomic policies i.e. zero interest

policy to small and medium enterprises and unlimited quantitative easing. These policies can help in reviving the economy.

An interesting analysis revealed that the stock market returns are not only influenced by the COVID-19 pandemic but it can also be influenced by the health measures taken by governments and their respective territories. The market efficiency cannot be only judged by the global pandemic but it can also be measured by the response measures taken by the ruling authorities. The macroeconomic policies, support measures, best health system and economic system have a greater impact on the volatility of financial markets rather than the COVID-19 pandemic. The US and Switzerland economies were dropped only by 11% during the pandemic period as compared to Spain or Italy (30% drop) because of having better economy and better health system than Spain and Italy, so economic policies and containment measures during the extreme situation has a big impact on the financial market performance (Capelle-Blancard and Desroziers, 2020).

2.2 Oil-Equity Nexus through Mean and Volatility Spillover

The oil-stock nexus is now so interconnected with each other that a shock in the oil market during some financial crisis or pandemics have a direct or indirect effect on the returns of stock market and vice versa. Similarly the oil market volatility can be used to predict the volatility of the equity markets.

Interdependence between oil market and stock market is a hot topic for the researchers especially during the era of certain global economic events and global crisis. The pandemic crisis in the world has certain consequences on the returns of oil market and equity markets. So when volatility is high in one market, it affects the other equity market as well. A number of studies explored the return and volatility relationship between world financial markets. Sakthivel et al. (2012) by using bivariate GARCH model explored the spillover between international financial markets. Weekly data was used covering the period 1998 to 2011. The five

well developed equity markets i.e. the U.S., the U.K., India, Japan and Australia were taken as a sample. The bidirectional volatility spillover was recorded between the United States and India which indicate that there is a strong bond between the two economies. The unidirectional spillover was recorded in case of Japan and the United Kingdom to India. The United States and Japan equity markets were also studied by Pan and Hsueh (1998) in the context of return and volatility transmission. Daily data was used from the period 1989 to 1993. Empirical finding by GARCH model revealed that the U.S. financial market had an influence on the Japan stock market. The returns and volatility of Japan equity market can be predicted from the return and volatility of the U.S. equity market.

The New York Stock exchange, Tokyo stock exchange and London stock exchange was also explored by Koutmos and Booth (1995) in the context of asymmetric volatility transmission. The multivariate EGARCH model was used on the daily stock returns covering the period 1986 to 1993. The results of this study indicate that there exist returns spillover and also volatility spillover from U.S. equity market to the U.K. and Japan financial markets, and also from Japan to U.K. equity market. Volatility spillover is also found to be significant from Japan to U.S., U.K. to Japan and U.S. Further results suggest the asymmetry in all the markets. The negative variations in all the equity markets were found to be more influential on the volatility of equity markets as compared to positive variations.

A multivariate GARCH-M model was used by Theodossiou and Lee (1993) to find the interdependence between some developed equity markets by using weekly data of stock market returns from the period 1980 to 1991. The findings of their study suggested that returns of U.S. influence the returns of U.K., Germany and Canada financial markets. Similarly the returns of German stock market were influenced by the returns of Japan equity markets. Furthermore the forecasted volatility has no value to predict to returns of all the equity markets. Further study indicate that volatility of U.S. stock market can be used to predict the volatility of all the four equity markets.

The U.K. market volatility can also be predicted from the Canadian financial market and so the Japan equity market volatility can be predicted from the

volatility of German equity market. The GARCH-M model, GJR GARCH and EGARCH model is used to study the volatility relationship between South Africa index and some developed markets i.e. Australia, China, U.K., Japan, Germany and the U.S. The daily data is used from 1995 to 2007. The bad news has caused more volatility in all the financial markets. Both the returns and volatility spillover exist between the South Africa and other indices. More importantly a quick transmission of volatility is observed in case of China, US and Australia. The quick transmission is due to the negative investor sentiment and other financial crisis (Chinzara and Aziakpono, 2009).

The new emerging Indian stock market is explored by Nath Mukherjee and Mishra (2010) with its other Asian counterparts in the context of market integration and volatility spillover. The GARCH (1, 1) model is used to determine the influence of Indian equity market with 12 other Asian equity markets. The daily opening and closing prices of all the indices are taken from the period 1997 to 2008. The purpose is to test the spillover during trading hours and non-trading hours. The findings of the study show that during trading hours, only Sri Lanka stock market have no influence on Indian stock market. All other financial market returns have a two-way relationship with India stock market in case of returns spillover. Further results reveal that over the night spillover is not strong from Asian counterparts to India financial market. The bidirectional volatility spillover is only found in case of Pakistan and Sri Lanka. The non-trading hours volatility is found to be significantly weak from India to other Asian countries.

Multivariate VAR-EGARCH model is used by In et al. (2001) to test the volatility transmission in between Hong Kong, Korea and Thailand during the 1997 Asian financial crisis. Daily data is used during the period February 3, 1997 till June 30, 1998. The lead-lag relationship is found to be stronger in case Hong Kong and Thailand which means there is a weak influence of Korea on these two markets. Furthermore the bidirectional volatility transmission occurs during the financial crisis in case of Hong Kong and Korea and unidirectional transmission occurs from Korea to Thailand. So these markets are more integrated during the Asian financial crisis and variations in these markets were not just because of the

local bad news but also because of each other. The spillover phenomenon is also investigated in case of six Asian countries financial markets i.e. Taiwan, India, Singapore, Japan, South Korea and Hong Kong. Daily data is used during the period 1985 to 2004. Bivariate VAR-GARCH model is used in this case. Positive volatility spillover is found in all the equity markets. In the geographical context, all the equity markets except India have a strong spillover effects between each other because they are geographically close to each other. So if the volatility today is high in one market, it will have an immediate influence on volatility of other equity market as well (Lee, 2009).

The oil market influence on the stock markets of developed countries, developing countries and emerging countries especially during the unfortunate situation of crisis are well investigated. Abdelhedi and Boujelbène-Abbes (2019) use the monthly and daily data of oil market index and Chinese stock indices for the period of 2006 to 2016 and discuss the nexus between Chinese financial market and crude oil market. Using BEKK-GARCH model, their results show a volatility transmission between oil market and Chinese stock market in both directions. The high volatility transmission is due to Chinese investor sentiment during the 2014-2016 China crises. So the investor confidence during the crises is gone beyond the expectation and so they sell their stocks and took a break from the financial market during the turmoil period. Using the daily data from 2009 to 2018, another study by Ashfaq et al. (2019) use the same methodology of BEKK-GARCH model to investigate the spillover between oil importing countries and oil exporting countries along with the crude oil prices. Bidirectional volatility transmission is found between oil market returns and stock market returns. The financial market variations are due its dependence on the oil market. The more they depend upon the oil market, the more will be shock transmission. Further results show that UAE is independent of the oil market. So their returns are not affected through the shocks of international crude oil market.

Boubaker and Raza (2017) in their study find strong evidence of time varying volatility in BRICS countries and crude oil market by using ARMA(1, 1), GARCH(1, 1)-DCC model. At different time horizons, the correlation is different.

During the 2008 financial crisis, the correlation between oil market and stock market is severely decreased due to panic situation and uncertainty and also due to the chaotic response of investors. They use the daily data of Brent crude oil, Brazil, Russia, India, China and South Africa from the period of 2000 to 2015. The study of Malik and Hammoudeh (2007) cover the oil-stock nexus between WTI crude oil, the U.S. financial market and three oil-rich Gulf countries i.e. Saudi Arabia, Kuwait and Bahrain by using daily data from the period of 1994 to 2001. The empirical findings of BEKK-GARCH model show that the returns and volatility of Gulf stocks are influenced by the crude oil market. Another interesting result is that only the Saudi stock market volatility is transmitted to the crude oil market. The United States stock market has indirectly affected the volatility of Gulf stock markets. The volatility transmission is due to high processing of information related to oil in between these countries.

Two supreme economic powers i.e. China and United States are examined with the international crude oil market by Liu et al. (2017) in the context of spillover from stock to oil and vice versa during the period of 2003 to 2016. The empirical findings of VAR-GARCH approach show that both the returns of U.S. and oil market are influenced by each other while volatility of U.S equity market is influenced by the crude oil market. There is no volatility transmission from U.S. equity market to oil market. Further results show that variations in the returns of oil market affect the returns of Chinese equity market. Moreover, the volatility transmission is negligible in case of Chinese equity market and crude oil market.

The shocks from oil market are transferred to stock markets returns. Sattary et al. (2014) use bivariate GARCH model with daily data of Borsa Istanbul (BIST) national market and world oil prices from 2002 to 2012 to investigate volatility spillover. The study find that oil consumption sectors are more attracted towards equity returns in terms of shocks. Bouri and Demirer (2016) investigate the spillover from the Brent oil market to emerging markets by using uni-variate GARCH approach. Daily closing prices of 10 emerging markets are used for the analysis covering the period from December 5, 2003 to April 5, 2014 which covers both pre and post-financial crisis period. The result of their study explore that

shocks in the oil market due to financial crisis were transmitted to the net oil importing emerging markets indicating that the returns and volatility of emerging markets can be forecasted from the shocks of the oil market.

Arouri et al. (2011) also document the return and volatility transmission between oil market and certain equity markets. The daily equity market prices of Bahrain, Kuwait, Oman, Qatar, UAE and Saudi Arabia are used from 2005 to 2010. The Brent crude oil prices are used in connection with the stock markets by using a VAR-GARCH approach. The six member Gulf Cooperation Council financial markets higher volatility is the result of higher oil market volatility because of the fluctuation in the international crude oil market. The oil market nexus with the GCC countries will help in improving the risk of uncertainty caused by the global financial crisis.

Now the main point here to explore is to know about the mean and volatility spillover between oil market and stock market in both directions during the COVID-19 pandemic. Very limited research has been done on the oil-stock nexus due to the pandemic crisis in the past. The fact that pandemic has a great influence on world major markets and oil market, so variations in oil market and equity market need to be explored in the area of mean and volatility spillover. The well-developed equity markets and new emerging markets had a great connection with the oil market because they consume almost 50% of world oil and they are major importers of the crude oil so they can be explored by studying their influence on each other during the unfortunate situation of pandemic.

2.3 Hypothesis of the Study

H1: There exists mean spillover from the oil market to equity market.

H2: There exists mean spillover from the equity market to oil market.

H3: There exists volatility spillover from the oil market to equity market.

H4: There exists volatility spillover from the equity market to oil market.

H5: Spillover from the equity market to oil market is high during the COVID-19

pandemic

H6: Spillover from the oil market to equity market is high during the COVID-19 pandemic.

Chapter 3

Research Methodology and Data Description

The methodology of this research is divided into two main parts. The first part is about spillover from the oil market (WTI) to the twelve developed and emerging equity markets (US, UK, Japan, France, Germany, Italy, Brazil, China, Russia, South Africa, India and Pakistan). The second part is about the spillover from the equity markets of developed countries and emerging countries to WTI (Western Texas Intermediate) during the COVID-19 pandemic.

The COVID dummy is used as an intercept and slope to determine the impact on spillover between equity market and oil market (WTI) in both directions. At first the COVID dummy is used with mean equation and then the COVID dummy is used with the volatility equation separately. This is actually a two stage ARMA GARCH (1, 1) in mean approach which is presented by Liu and Pan (1997) in which shocks are created from one series in the first stage and then those shocks are added to another series to find the impact of one market on another market through mean and volatility equation in the second stage.

3.1 Sample of the Study

The sample of the study is comprised of six developed markets and six emerging markets along with the crude oil market (WTI). Developed countries include US,

UK, Japan, Germany, Italy and France. Emerging markets include Pakistan, India, China, Brazil, South Africa and Russia. For the oil market Western Texas Intermediate (WTI) is used for analysis.

Table 3.1 has all the details about the equity indices used for this study along with its symbol and country name. The financial times series data is generally non stationary in nature so we convert the daily closing prices of all the equity markets to returns series because for volatility modeling the data must be in stationary form.

TABLE 3.1: Developed and Emerging Equity Markets

S. No.	Equity Markets	Symbol	Country
1	National Association Of Securities Dealers Automated Quotations Exchange	**NASDAQ100**	US
2	Financial Times Stock Exchange	**FTSE100**	UK
3	Tokyo Price Index	**TOPIX1000**	Japan
4	Deutscher Aktienindex	**DAX**	Germany
5	Italy 50 Index	**ITALY50**	Italy
6	Continuous Assisted Trading	**CAC**	France
7	Pakistan Stock Exchange	**KSE100**	Pakistan
8	Bombay Stock Exchange	**BSE500**	India
9	Bolsa de Valores de Sao Paulo	**BOVESPA**	Brazil
10	Russian Trading System Index	**RTSI**	Russia
11	South Africa 40 Index	**SA40**	South Africa
12	Shenzhen Stock Exchange	**SZSE**	China

The returns of WTI and equity markets can be calculated by the following formula:

Return = log (P_t / P_{t-1}); Where Return = Return of WTI index and equity market index; P_t = Current day closing prices at time "t"; P_{t-1} = Previous day closing prices at time "t-1".

3.2 Timeline of the Study

Daily data of the oil market (WTI) and stock indices are used. The timeline of this study is taken from the period 1st January 2010 to 9th October 2020. The COVID period is taken from the 1st February 2020 to 9th October 2020. The COVID duration has taken the values of 1 while for the rest of the period it is 0.

3.3 Econometric Model

3.3.1 Spillover from the Stock Market to the Oil Market during the COVID-19 Pandemic

This study identify the impact of COVID-19 on mean and volatility of stock returns by constructing a dummy variable, named COVID, which will take the value of 1 for observations during 1st February 2020 till 9th October 2020 and 0 for the rest of the period. Apart from mean and volatility equation, this study multiply COVID dummy with mean and volatility spillover but not at the same time. First we use dummy for returns and then we use COVID dummy for volatility. If results are significant then we conclude that spillover is different in COVID period than before. If results are insignificant then it means that there is no different impact of the COVID-19 on mean and volatility of stock returns.

At first stage the ARMA (1, 1)-GARCH (1, 1)-M model proposed by Liu and Pan (1997) is used to examine the mean and volatility transmission from stock market to the oil market. The mean equation and volatility equation of the equity market is shown in equation 3.1.

$$\begin{cases} R_{s,t} = \beta_o + \beta_1.R_{s,t-1} + \beta_2.\mu_{s,t-1} + \beta_3.\sqrt{\sigma}_{s,t} + \epsilon_{s,t} \\ \sigma^2_{s,t} = \gamma_o + \gamma_1.\mu^2_{s,t-1} + \gamma_2.\sigma^2_{s,t-1} \end{cases} \tag{3.1}$$

where $R_{s,t}$ is the daily returns of the stock market, $R_{s,t-1}$ is the lagged value of the stock returns , $\mu_{s,t-1}$ is the moving average term or lagged residual term, $\sqrt{\sigma}_{s,t}$ is the forecasted volatility and $\epsilon_{s,t}$ is the shock or unexpected returns of the stock market. $\sigma_{s,t}$ is the forecasted volatility of the stock market. It depend on lagged squared error term $\mu^2_{s,t-1}$ of the stock market and lagged forecasted variance $\sigma^2_{s,t}$

of the stock market. In the second stage, the mean and volatility spillover from the equity market to the oil market is determined by the shocks obtained from the stock market in the first stage. Now those shocks obtained are added to mean and volatility equation of the oil market that is modeled by ARMA (1, 1)-GARCH (1, 1) or GJR-GARCH.

$$\begin{cases} R_{o,t} = \beta_o + \beta_1.R_{o,t-1} + \beta_2.\mu_{o,t-1} + \beta_3.\sqrt{\sigma}_{o,t} \\ \quad +\beta_4.\lambda_{s,t} + \beta_5.COVID + \beta_6.\lambda_{s,t} * COVID \\ \sigma^2_{o,t} = \gamma_o + \gamma_1.\mu^2_{o,t-1} + \gamma_2.\mu^2_{o,t-1}d_{o,t-1} + \gamma_3.\sigma^2_{o,t-1} + \gamma_4\phi^2_{s,t} \end{cases} \tag{3.2}$$

Where $R_{o,t}$ is the daily returns of the oil market, $R_{o,t-1}$ is the autoregressive term, $\mu_{o,t-1}$ is the MA term, $\lambda_{s,t}$ indicates the mean spillover from stock market to the oil market, $\phi^2_{s,t}$ represent the volatility spillover from stock market to the oil market. $\mu^2_{o,t-1}d_{o,t-1}$ represent the GJR-GARCH. Equation 3.2 shows that shocks from the equity market are added to the oil market. There is also an addition of intercept and slope dummy of COVID to find the impact of the COVID-19 pandemic on returns of oil market.

$$\begin{cases} R_{o,t} = \beta_o + \beta_1.R_{o,t-1} + \beta_2.\mu_{o,t-1} + \beta_3.\sqrt{\sigma}_{o,t} + \beta_4.\lambda_{s,t} \\ \sigma^2_{o,t} = \gamma_o + \gamma_1.\mu^2_{o,t-1} + \gamma_2.\mu^2_{o,t-1}d_{o,t-1} + \gamma_3.\sigma^2_{o,t-1} \\ \quad +\gamma_4\phi^2_{s,t} + \gamma_5 COVID + \gamma_6\phi^2_{s,t} * COVID \end{cases} \tag{3.3}$$

Equation 3.3 shows the COVID-19 impact on the volatility of the oil market. Now the COVID dummy is added as an intercept and slope to the volatility equation to find the impact of COVID-19 on volatility of the oil market (WTI) during COVID period and before COVID period.

The subscript o represents the oil market and the subscript s represent the equity market. The volatility spillover parameter is calculated as:

$$\phi^2_{o,t} = residual^2_{s,t}/GARCHvarianceseries_{s,t}$$

3.3.2 Spillover from the Oil Market to Equity Market During the COVID-19 Pandemic

The working will be reversed in order to find the spillover from the oil market to equity market. ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used in the first stage.

$$\begin{cases} R_{o,t} = \beta_o + \beta_1.R_{o,t-1} + \beta_2.\mu_{o,t-1} + \beta_3.\sqrt{\sigma}_{o,t} + \epsilon_{o,t} \\ \sigma^2_{o,t} = \gamma_o + \gamma_1.\mu^2_{o,t-1} + \gamma_2.\sigma^2_{o,t-1} \end{cases} \tag{3.4}$$

The shocks are created from the oil market as shown in equation 3.4.

$$\begin{cases} R_{s,t} = \beta_o + \beta_1.R_{s,t-1} + \beta_2.\mu_{s,t-1} + \beta_3.\sqrt{\sigma}_{s,t} \\ +\beta_4.\lambda_{o,t} + \beta_5.COVID + \beta_6.\lambda_{o,t} * COVID \\ \sigma^2_{s,t} = \gamma_o + \gamma_1.\mu^2_{s,t-1} + \gamma_2.\mu^2_{s,t-1}d_{s,t-1} + \gamma_2.\sigma^2_{s,t-1} + \gamma_3\phi^2_{o,t} \end{cases} \tag{3.5}$$

In the second stage the residual series created from the oil market is added to stock market to find the mean spillover $\lambda_{o,t}$ and volatility spillover $\phi^2_{o,t}$ from the oil market to equity market. In equation 3.5, ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used for spillover and asymmetric behavior. Intercept and slope dummy of COVID is also added to the mean equation to identify the mean spillover during COVID period and before COVID period.

$$\begin{cases} R_{s,t} = \beta_o + \beta_1.R_{s,t-1} + \beta_2.\mu_{s,t-1} + \beta_3.\sqrt{\sigma}_{s,t} + \beta_4.\lambda_{o,t} \\ \sigma^2_{s,t} = \gamma_o + \gamma_1.\mu^2_{s,t-1} + \gamma_2.\sigma^2_{s,t-1} + \gamma_3.\mu^2_{s,t-1}d_{s,t-1} \\ +\gamma_4\phi^2_{o,t} + \gamma_5.COVID + \gamma_6\phi^2_{o,t} * COVID \end{cases} \tag{3.6}$$

In equation 3.6 Intercept and slope dummy is added to the volatility equation to find the volatility difference during COVID period and before COVID period. Finally, it comes to know about the impact of COVID-19 pandemic on the oil market through the abnormal movements in the equity market and the impact of COVID-19 pandemic on the equity market through the shocks of the oil market.

Chapter 4

Data Analysis and Discussion

This chapter provides the result of spillover from the oil market to equity market and equity market to the oil market and identify the impact of the COVID-19 pandemic on the oil market and equity market through various tests.

4.1 Graphical Representation

4.1.1 Stationarity of Data

The first step to do the analysis is to take feel of the data through visualization that either the data is stationary or non-stationary. Usually economic time series data is non stationary in nature but when we convert the data into return series then the data become stationary. Stationarity of data means that mean is constant and does not change over time.

However due to volatility clustering variance is not constant. When variance is not constant then it means that data is heteroskedastic. It can be clearly seen in the attached graphs that mean is constant for all the time series data and there are some wild period of volatility at the year 2020 which clearly gives the indication of the COVID-19 impact as shown in Appendix-A.

4.2 Descriptive Statistics

Descriptive statistics is used to know about the statistical behavior of the data. It includes three things i.e. location of the data, measure of central tendency and measure of dispersion. Location of the data can be observed by looking at the kurtosis and skewness of the data. Measure of central tendency can be seen by arithmetic mean and median. The standard deviation of the data shows the average risk per day which is a measure of dispersion. This section provides with three phases of descriptive statistics i.e. descriptive statistics during 1st January 2010 to 9th October 2020 which includes both the COVID and non COVID period. The second phase of descriptive statistics is based on the assumption of the COVID period that starts from 1st February 2020 to 9th October 2020. The third phase is descriptive statistics with the assumption of non COVID period that employs from 1st January 2010 to 31st December 2019.

4.2.1 COVID Period and Non COVID Period Statistics

Table 4.1 shows the mean, maximum and minimum returns per day, skeweness and kurtosis of the WTI, emerging markets and developed market. By looking at the statistics of WTI oil market, average return of the oil market (WTI) is negative which is 0.0239% per day. The maximum return earned in a day is 31.96% and maximum loss incurred in a day is 60.16%. The average risk of the oil market is 2.84% per day. Data is negatively skewed indicating the higher negative returns in some days. The kurtosis indicates that data is peaked in nature so it exhibit leptokurtic behavior.

The average return for the Brazil equity market (Bovespa) is 0.0127% per day. 31.02% is the maximum return earned in a day while maximum loss incurred in a day is 15.99%. The average risk recorded is 1.55% per day. The behavior of the data is leptokurtic in nature and skewness shows that there are more negative returns in some days. The kurtosis value is more than 3 for all the equity market returns which means the behavior is leptokurtic for emerging market returns and developed market returns, so we conclude that data is peaked in nature.

TABLE 4.1: Descriptive Statistics for the Period 1st January 2010 to 9th October 2020 with the Assumption of COVID and Non COVID Period

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WTI	**-0.000239**	**0.319634**	**-0.601676**	**0.028428**	**-3.135616**	**95.52241**
BOVESPA	0.000127	0.130228	-0.159938	0.015569	-0.864325	15.97664
RTSI	-0.0000768	0.132462	-0.139486	0.017756	-0.649908	11.54642
BSE500	0.000303	0.074933	-0.137891	0.010408	-1.245038	19.86632
SZSE	-0.0000108	0.062542	-0.088245	0.015859	-0.747169	7.178598
SA40	0.000252	0.079071	-0.104504	0.011277	-0.511883	9.931053
KSE100	0.000523	0.04684	-0.071024	0.010042	-0.606917	7.682473
NASDAQ100	0.000654	0.095966	-0.130032	0.012284	-0.665873	13.70071
FTSE100	0.0000376	0.086668	-0.115124	0.010316	-0.77526	13.87921
TOPIX1000	0.000208	0.077831	-0.09871	0.012079	-0.465974	9.263606
DAX	0.000279	0.104143	-0.130549	0.012745	-0.55548	11.22704
ITALY50	-0.0000618	0.106857	-0.182014	0.015805	-0.975382	14.11124
CAC	0.000147	0.08143	-0.124211	0.011842	-0.691708	12.03633

Where BOVESPA=Brazil stock market; RTSI=Russia stock market; BSE500= India equity market; SZSE=China stock market; SA40=South Africa financial market; KSE100=Pakistan equity market; NASDAQ100=U.S. stock market; FTSE100=U.K. stock market; TOPIX1000=Japan equity market; DAX=Germany financial market; CAC= France equity market

Also there is a clear indication that data is negatively skewed for all the equity markets which means there are larger negative returns.

On average the return for Russia stock market (RTSI) is -0.00768% per day. For India the average return is 0.0303% per day. The china stock market (SZSE) has -0.00108% average return per day. South Africa equity market (SA-40) has a daily average of 0.0252%. Equity market of Pakistan has an average return of 0.0523% per day. United States equity market (NASDAQ100) has the highest average return of 0.0654% per day. If we look at the average return of the UK stock market (FTSE100), it is 0.00376% on average per day. Similarly Japan financial market (TOPIX1000) has an average return of 0.0208% per day. The Germany stock market (DAX), Italy equity market (ITALY-50) and French equity market (CAC) has an average return per day is 0.0279%, -0.00618% and 0.0147% respectively.

The average risk per day for Brazil, Russia, India, China, South Africa and Pakistan is 1.56%, 1.78%, 1.04%, 1.58%, 1.13% and 1.00% respectively. US, UK, Japan, Germany, Italy and France has an average per day risk of 1.23%, 1.03%, 1.20%, 1.27%, 1.58% and 1.18%. The maximum return and maximum loss incurred in a day for Russia equity market is 13.25% and 13.94%. India has earned a maximum return of 7.49% in a day and maximum loss in a day is recorded 13.79%. Around 6.25% is the maximum return earned by China financial market in a day while maximum loss is 8.8%. The South Africa stock market has the maximum return of 7.9% in a day while maximum loss in a day is 10.45%.

Pakistan stock exchange has the lowest maximum return earned in a day among emerging and developed markets which is 4.68% and 7.1% is the maximum loss in a day. The US financial market has a maximum return of 9.59% in a day and a maximum loss of 7.1% in a single day. 8.66% is the maximum return earned in a day by the UK financial market and 11.51% is the maximum loss incurred in a day. Equity market of Japan has a maximum loss of 9.87% in a day while maximum gain recorded is 7.78% in a day. There is a maximum gain of 10.41% and a maximum loss of 13.05% in a day for Germany equity market. The maximum gain for Italy stock exchange and France stock market is 10.68% and 8.1% in a

TABLE 4.2: Descriptive Statistics for the Period 1st February 2020 to 9th October 2020 with the Assumption of the COVID Period

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WTI	**-0.001176**	**0.319634**	**-0.601676**	**0.0818**	**-2.07456**	**21.65616**
BOVESPA	-0.000868	0.130228	-0.159938	0.032478	-1.24524	10.79858
RTSI	-0.001494	0.088251	-0.139486	0.028239	-1.241356	8.769058
BSE500	0.000042	0.074933	-0.137891	0.021689	-1.861617	13.88818
SZSE	0.001713	0.040081	-0.055216	0.016726	-0.733456	4.797442
SA40	0.0000974	0.079071	-0.104504	0.021848	-0.888608	8.001759
KSE100	0.0000535	0.04684	-0.071024	0.016559	-1.291655	7.982184
NASDAQ100	0.001377	0.095966	-0.130032	0.026149	-0.760437	8.02571
FTSE100	-0.0011	0.086668	-0.115124	0.020844	-0.999081	9.46638
TOPIX1000	-0.0000936	0.067154	-0.057538	0.015479	-0.022743	6.155293
DAX	2.59E-06	0.104143	-0.130549	0.023336	-0.862408	10.35796
ITALY50	-0.001014	0.086738	-0.182014	0.025735	-2.478581	18.63566
CAC	-0.000744	0.079407	-0.124211	0.021805	-1.215823	9.823046

Where BOVESPA=Brazil stock market; RTSI=Russia stock market; BSE500= India equity market; SZSE=China stock market; SA40=South Africa financial market; KSE100=Pakistan equity market; NASDAQ100=U.S. stock market; FTSE100=U.K. stock market; TOPIX1000=Japan equity market; DAX=Germany financial market; CAC= France equity market

single day while loss incurred is 18.2% and 12.42% in a day. If we look at the average risk per day for the financial markets, we can see that the Russia, China and Brazil has the highest average risk per day i.e. 1.78%, 1.5859% and 1.5569% respectively. The lowest average risk recorded is by Pakistan and India which is 1.0042% and 1.0408% per day. The fourth highest average risk per day is 1.5805% by Italy stock market. South Africa and France has an average risk of 1.12% and 1.18% per day. The average risk for the US financial market is 1.23% per day. UK, Japan and Germany have an average risk of 1.03%, 1.20% and 1.27% per day respectively.

4.2.2 The COVID Period Statistics

Table 4.2 represents the COVID period statistics. The location of the data is clearly observed by the skewness and kurtosis which shows that all the data is negatively skewed so there are large negative returns during the COVID period. Data is peaked in nature which means the behavior is leptokurtic in nature during the COVID period. The average return during the COVID pandemic for WTI is -0.1176% per day with the maximum value of 31.96% and maximum loss of 60.17%. The average risk recorded during the COVID period is 8.18% for WTI. During the COVID period the measure of dispersion for BRICS countries are 3.24%, 2.82%, 2.16%, 1.67% and 2.18% on average. In developed countries the highest average risk is recorded by US and Italy with 2.6% and 2.57% per day. Germany also has a highest average risk during the COVID period i.e. 2.33% per day.

During the COVID-19 pandemic the average risk per day for Japan, UK and France are 1.54%, 2.08% and 2.18% respectively. Along with Japan, Pakistan also has a lowest average risk per day (1.65%) during the COVID period. The highest maximum gain is recorded by Brazil (13%) with Germany (10.4%) in a single day. The Italy stock market is crashed with the maximum loss of 18.2% during the COVID period. Russia, India and US financial market are affected badly by the pandemic with the maximum loss of 13.9%, 13.78% and 13% in a day. Only china is less affected with the maximum loss of 5.5% because they recovered themselves so quickly from the COVID-19 pandemic. Brazil, France, Germany and South Africa

are also among those countries whose stock markets are affected. The maximum loss incurred during the COVID period is 15.99%, 12.42%, 13.05% and 10.45% per day respectively.

Average returns per day are also drop down due to the COVID-19 pandemic. The Brazil market and Russia market are recorded with negative daily returns on average while India, China and South Africa show positive on average daily returns. The on average return for BRICS countries are -0.00868%, -0.1494%, 0.0042%, 0.1713% and 0.00974% respectively. If we look at the developed countries average per day return, the UK market, Japan, France and Italy has a negative daily average return with the values of -0.11%, -0.00936%, -0.0744% and -0.1014% per day. US, Germany and Pakistan has positive daily average returns with 0.1377%, 0.000259% and 0.00535% respectively.

4.2.3 Non COVID Period Statistics

Table 4.3 shows the descriptive statistics with the assumption of non COVID period. By looking at the daily average returns of BRICS countries and developed countries during non COVID period, only China stock market (SZSE) has the on average negative returns i.e. 0.0105% per day. US financial market (NASDAQ100) has the highest average return i.e. 0.0593% per day while Italy stock market has the lowest average daily return (0.00257%) among developed countries. India equity market (BSE500) has the second highest average daily returns (0.0332%) with South Africa (0.0272%) to follow next in the BRICS economies.

The on average returns for the remaining BRICS countries is low for Russia equity market (RTSI) with the value of 0.00267% per day while Brazil (BOVESPA) has recorded a second lowest figure 0.02% per day. Equity market of Pakistan (KSE100) has a daily average of 0.0563% during non COVID period. Developed countries have low daily average returns than Pakistan except United States. Germany has better average daily returns (0.0307%) than Japan (0.0242%) and France (0.0217%) during non COVID period. UK has recorded the low average daily returns with the value of 0.0127%.

Table 4.3: Descriptive Statistics for the Period 1st January 2010 to 31st December 2019 with the Assumption of the Non COVID Period

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WTI	**-0.000101**	**0.136944**	**-0.090703**	**0.020272**	**0.107588**	**6.312535**
BOVESPA	0.0002	0.063874	-0.09211	0.013701	-0.166437	5.186474
RTSI	0.0000267	0.132462	-0.132545	0.016849	-0.38787	10.5065
BSE500	0.000332	0.052028	-0.069049	0.009161	-0.253834	5.804202
SZSE	-0.000105	0.062542	-0.086036	0.015736	-0.701606	7.178577
SA40	0.000272	0.046786	-0.040493	0.010181	-0.135044	4.521938
KSE100	0.000563	0.044186	-0.04765	0.009399	-0.296506	5.350855
NASDAQ100	0.000593	0.05978	-0.063053	0.010731	-0.391055	6.299509
FTSE100	0.000127	0.050323	-0.061994	0.009185	-0.279166	6.306189
TOPIX1000	0.000242	0.077831	-0.09871	0.011842	-0.527739	9.588463
DAX	0.000307	0.052104	-0.070673	0.011706	-0.289426	5.830338
ITALY50	0.00000257	0.106857	-0.129895	0.014929	-0.356038	7.69937
CAC	0.000217	0.08143	-0.072105	0.010865	-0.242273	7.241994

Where BOVESPA=Brazil stock market; RTSI=Russia stock market; BSE500= India equity market; SZSE=China stock market; SA40=South Africa financial market; KSE100=Pakistan equity market; NASDAQ100=U.S. stock market; FTSE100=U.K. stock market; TOPIX1000=Japan equity market; DAX=Germany financial market; CAC= France equity market

The on average return for oil market is negative (0.0101%) with the maximum return (13.6944%) and maximum loss incurred (9.0703%) during the non COVID period. The average risk recorded during this phase is 2.0272% per day.The data is positively skewed which means there were more positive returns in some days for WTI oil market. Data is peaked in nature for WTI because the value of kurtosis is more than 3 which exhibit leptokurtic behavior. The markets with more average risk per day during non COVID period are Russia (1.68%), China (1.57%), Italy (1.49%) and Brazil (1.37%) while the markets who are at low risk during this period are UK (0.9185%), India (0.9161%) and Pakistan (0.9399%). Japan and Germany have almost same average risk per day i.e. 1.18% and 1.17% during non COVID period. US and France has an average risk per day (1.07%) and (1.08%) which is almost same for both economies during non COVID period while South Africa has recorded 1.01% average risk daily.

The Russia and Italy has recorded the highest maximum loss with the values of 13.25% and 12.98% in a day during non COVID period. The maximum return earned in a day during COVID period and non COVID period show a huge difference by the oil market because during COVID period the figure was 31.96% while during non COVID period it is 13.69%. Also if we look at the loss incurred by oil market it is 60% during the COVID period while in non COVID period the maximum loss incurred is only 9.07% in a single day. Brazil has the maximum return of 6.38% with the maximum loss of 9.2% in a day. Russia has same ratio of maximum return and maximum loss provoked with the value of 13.2% in a day. By the developed markets only Italy has the highest maximum return earned in a day with the figure of 10.68% during non COVID period and U.K. has the lowest maximum return with the value of 5.03% on average in a single day.

4.3 Mean Spillover from WTI to Equity Markets during the COVID-19 Pandemic

The first objective of the study is to determine mean spillover from the oil market (WTI) to equity markets of developed and emerging countries during the crisis of

COVID-19 pandemic by using an econometric model.

Table 4.4 identify the parameters of mean spillover from WTI to equity markets of US (NASDAQ100), UK (FTSE100), France (CAC) and Germany (DAX) during the event of COVID-19 period by the process of ARMA (1, 1)-GJR-GARCH (1,1)-M model. The COVID dummy is being used as an intercept dummy β_5 and slope dummy β_6 to determine the impact of the COVID-19 pandemic on financial markets. The intercept and slope dummy is used separately with the mean and volatility equation in order to find the pandemic impact on returns and volatility. All lagged values and ARCH GARCH parameters are reported with their p-value (in parenthesis). The model selection is on the basis of lowest Akaike Information Criteria (AIC). Here the purpose is to identify the shocks created by the pandemic in the oil market and how these shocks are transmitted to the returns of the equity market.

For WTI, the coefficient of β_1 is proved to be insignificant which indicates that the oil market is efficient because the returns of oil markets are not predicted by the past day returns. The coefficient of standardized residual error term, β_2 for WTI is also insignificant which means that the oil market returns cannot be forecasted on the basis of past shocks. Furthermore we can say that the oil market did not make necessary adjustments for the next day on the basis of past abnormal movements. If we look at the parameter of GARCH in mean β_3 for WTI, the result is significant which confirms that current day returns of the oil market can be predicted on the basis of forecasted volatility.

The coefficient of ARCH term, γ_1 for WTI is positive and significant which means current period volatility can be influenced by the past price behavior in the oil market. Similarly the coefficient of GARCH term, γ_2 in case of WTI is positively significant which means there is persistence of volatility in the oil market. If we look at the sum of the coefficients of γ_1 and γ_2, it is 0.99 which is closer to 1 for WTI. So it confirms that persistence of volatility is longer in run in the oil market. In case of equity markets the parameter of GJR GARCH, γ_3 is significant for the markets of US (NASDAQ100), Germany (DAX) and France (CAC) which confirms that there is asymmetric behavior in these markets. It means that when

TABLE 4.4: Mean Spillover from the Oil market to Equity Market during the COVID-19 pandemic ARMA-GJR-GARCH-M Model

	WTI	**NASDAQ100**	**FTSE100**	**DAX**	**CAC**
β_0	**-0.0033**	0.0001	-0.0022	-0.001	-0.0007
	(0.0013)	(0.8248)	(0.0000)	(0.1008)	(0.1425)
β_1	**0.3554**	-0.0104	0.2017	0.0935	0.1482
	(0.3019)	(0.8650)	(0.0003)	(0.1877)	(0.0441)
β_2	**-0.3784**	-0.0339	-0.218	-0.0859	-0.1282
	(0.2678)	(0.5909)	(0.0003)	(0.2385)	(0.0918)
β_3	**0.1671**	0.0348	0.2768	0.0983	0.0649
	(0.0020)	(0.5542)	(0.0000)	(0.1237)	(0.2359)
β_4	-	0.0024	0.0024	0.0023	0.0019
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)
β_5	-	0.002	-0.0013	0.0013	0.0009
	-	(0.0097)	(0.0462)	(0.0325)	(0.0604)
β_6	-	0.0053	0.0016	0.0038	0.003
	-	(0.0000)	(0.0001)	(0.0000)	(0.0000)
γ_0	**7.11E-06**	1.65E-06	1.37E-06	4.39E-08	8.92E-07
	(0.0000)	(0.0111)	(0.0051)	(0.9396)	(0.0834)
γ_1	**0.1061**	0.0345	0.1114	0.0004	-0.007
	(0.0000)	(0.0000)	(0.0000)	(0.9585)	(0.3875)
γ_2	**0.8872**	0.8141	0.829	0.9084	0.8598
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_3	-	0.1709	-	0.1154	0.2119
	-	(0.0000)	-	(0.0000)	(0.0000)
γ_4	-	5.57E-06	3.47E-06	4.11E-06	3.78E-06
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Where NASDAQ100 = US financial market, FTSE100 = UK stock market, DAX = Germany stock index, CAC = France Equity market, WTI = crude oil market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept with returns and β_6 denotes the parameter of COVID slope with mean spillover, γ_3 denotes the parameter of GJR-GRACH, γ_4 denotes the parameter of volatility spillover

the COVID news entered into these markets, it created more volatility. In case of UK (FTSE100) there is no asymmetric behavior in the market. Whether if there is COVID news or good news when enter into the UK market, it will have the same effect. Simply we can say that the UK market has the same reaction for good news as well as bad news.

For equity markets the coefficients of Autoregressive term, moving average term, GARCH in mean are explained later in the section of Mean Spillover from equity market to the oil market during the COVID-19 pandemic. The coefficient of ARCH and GARCH term for all the equity markets are also explained with detail later in the section of Volatility spillover from equity market to the oil market during the COVID-19 pandemic. So here the discussion will only be about the mean spillover β_4 from the oil market to equity market, volatility spillover γ_4 from the oil market to equity market, COVID period β_5 (intercept dummy) relationship with normal period and COVID period spillover β_6 with normal period spillover (slope dummy).

In Table 4.4 the results of mean spillover β_4 is significant and positive from WTI to all the equity markets. It means that variations in the oil market returns transmit to the equity markets returns of US (NASDAQ100), UK (FTSE100), Germany (DAX) and France (CAC). Positive sign is the indication that these markets are moving in same direction with the oil market. High returns of the oil market result in the higher returns for the equity markets like US, UK, Germany and France. Now the purpose is to see the returns of these markets during the COVID-19 pandemic and normal period, so the results of COVID intercept, β_5 is significant for all the equity markets which indicates that there is a big difference between the COVID period returns and normal period returns. The sign is positive for US, Germany and France which means that in these markets returns are high during the COVID period while for UK (FTSE100), the COVID period returns are low (negative sign) as compared to normal period returns.

The parameter of COVID slope β_6 is significant and positive for WTI to all the equity markets which provide the evidence that mean spillover is different during the COVID-19 pandemic. Financial markets like US, UK, Germany and

TABLE 4.5: Mean Spillover from the Oil market to Equity Market during the COVID-19 period - ARMA-GJR-GARCH-M Model

	WTI	**RTSI**	**BSE500**	**SA40**	**ITALY50**	**TOPIX1000**
β_0	**-0.0033**	-0.0014	-0.0007	-0.0014	-0.0014	-0.0004
	(0.0013)	(0.0723)	(0.2739)	(0.0033)	(0.0852)	(0.3127)
β_1	**0.3554**	0.3511	0.2603	0.2875	0.0617	0.6546
	(0.3019)	(0.0000)	(0.0029)	(0.0000)	(0.3518)	(0.0000)
β_2	**-0.3784**	-0.3556	-0.1611	-0.3253	-0.0999	-0.6547
	(0.2678)	(0.0000)	(0.0770)	(0.0000)	(0.1441)	(0.0000)
β_3	**0.1671**	0.0661	0.0906	0.1443	0.0845	0.0484
	(0.0020)	(0.2578)	(0.2258)	(0.0088)	(0.2077)	(0.2129)
β_4	-	0.0049	0.0011	0.0022	0.0029	0.001
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
β_5	-	-0.0003	0.0007	0.0003	0.0006	-
	-	(0.6824)	(0.3181)	(0.5265)	(0.4591)	-
β_6	-	0.0024	0.00145	0.002	0.0038	0.0009
	-	(0.0062)	(0.0006)	(0.0000)	(0.0000)	(0.0578)
γ_0	**7.11E-06**	-3.46E-07	3.14E-06	5.98E-07	2.94E-06	2.79E-06
	(0.0000)	(0.7314)	(0.0000)	(0.3304)	(0.0048)	(0.0018)
γ_1	**0.1061**	0.0212	-0.0073	-0.0041	0.0151	0.1123
	(0.0000)	(0.0004)	(0.3147)	(0.5645)	(0.0559)	(0.0000)
γ_2	**0.8872**	0.902	0.8615	0.8959	0.8825	0.8498
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_3	-	0.0885	0.1676	0.1296	0.1268	-
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	-
γ_4	-	8.22E-06	2.07E-06	3.76E-06	4.71E-06	2.83E-06
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)

Where RTSI = Russian security market, BSE500 = India equity market, SA40 = South Africa stock index, ITALY50 = Italy equity market, TOPIX1000 = Japan equity market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept with returns, 6 denotes the parameter of COVID slope with mean spillover. γ_3 denotes the parameter of GJR-GRACH and γ_4 denotes the parameter of volatility spillover

France have higher returns spillover from the oil market during the COVID period because the sign is positive in case of all these markets. The COVID-19 pandemic has given big shocks to the returns of oil market which are followed by higher returns in these equity markets. So the returns of these equity markets are highly affected due to the COVID-19 pandemic.

Table 4.5 show the measure of mean spillover from WTI to the financial markets during the COVID period by the process of ARMA (1, 1)-GJR-GARCH (1, 1)-M model. Equity markets include Russia (RTSI), India (BSE500), South Africa (SA40), Italy (ITALY50) and Japan (TOPIX1000). The COVID dummy is used as an intercept dummy β_5 and slope dummy β_6 to determine the impact of the COVID-19 pandemic on the returns of these financial markets. The results of mean spillover β_4 from WTI to all the equity markets are significant and positive. So we conclude that if the returns of the oil market are changed, the financial market returns of Russia (RTSI), India (BSE500), South Africa (SA40), Japan (TOPIX1000) and Italy respond to it. Positive sign shows that if the variation in the oil market returns is high, the equity markets variation is also be high.

The results of intercept dummy, β_5 are insignificant which shows that returns are same for both COVID and non COVID period in financial markets like Russia, India, South Africa, Italy and Japan. There is no change in the returns of these equity markets when the COVID news enters into the market. If we want to see the impact of the COVID-19 pandemic on mean spillover β_6, the results are significant positively for all the equity markets. It means that returns spillover between WTI and Russia, WTI and India, WTI and South Africa, WTI and Italy and WTI and Japan is different when COVID news enters into these markets. Simply we can say that the COVID period spillover and normal period spillover is different. The positive sign is the indication of high returns spillover from the oil market to stock market during the COVID-19 pandemic.

The impact of the COVID-19 pandemic is clearly justified because it has produced big shocks in the oil market returns and then those shocks are transmitted to the returns of equity markets in a big manner. For asymmetric behavior in financial markets we will see the coefficient of GJR GARCH γ_3 which shows asymmetric

TABLE 4.6: Mean Spillover from the Oil market to Equity Market during the COVID-19 crisis - ARMA-GJR GARCH-M Model

	WTI	**KSE100**	**SZSE**	**BOVESPA**
β_0	**-0.0033**	0.0009	-0.0008	-0.0015
	(0.0013)	(0.1658)	(0.3036)	(0.1659)
β_1	**0.3554**	0.2281	0.5242	0.0167
	(0.3019)	(0.0233)	(0.0000)	(0.7687)
β_2	**-0.3783**	-0.0444	-0.532	-0.0472
	(0.2678)	(0.6659)	(0.0000)	(0.4169)
β_3	**0.1671**	-0.0501	0.0422	0.0941
	(0.0020)	(0.4965)	(0.4249)	(0.2989)
β_4	-	-7.15E-05	0.0013	0.0042
	-	(0.6584)	(0.0000)	(0.0000)
β_5	-	0.0007	0.0009	0.0013
	-	(0.1908)	(0.1116)	(0.2426)
β_6	-	0.0017	0.0019	0.0007
	-	(0.0007)	(0.0231)	(0.4808)
γ_0	**7.11E-06**	4.39E-06	2.68E-06	5.30E-06
	(0.0000)	(0.0000)	(0.0002)	(0.0006)
γ_1	**0.1061**	0.0079	0.0449	0.0366
	(0.0000)	(0.3888)	(0.0000)	(0.0005)
γ_2	**0.8872**	0.8156	0.9447	0.864
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_3	-	0.2409	-	0.0808
	-	(0.0000)	-	(0.0000)
γ_4	-	1.34E-06	-1.06E-07	5.61E-06
	-	(0.0076)	(0.8502)	(0.0000)

Where KSE100 = Pakistan stock exchange, SZSE = China equity market, BOVESPA = Brazil equity market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept with returns, β_6 denotes the parameter of COVID slope with mean spillover, γ_3 denotes the parameter of GJR-GRACH and γ_4 denotes the parameter of volatility spillover

behavior in equity markets of Russia, India, South Africa and Italy irrespective of Japan equity market because there is no asymmetry in Japan stock market. Bad news of COVID-19 has created more volatility in financial markets of India, Russia, South Africa and Italy while in case of Japan, good or bad news has the same effect on the volatility.

Table 4.6 shows the parameters of mean spillover from WTI to equity markets during the COVID-19 pandemic through the process of ARMA (1, 1)-GJR-GARCH (1, 1)-M model. Pakistan equity markets (KSE100), China financial market (SZSE) and Brazil stock market (BOVESPA) have some interesting results. The results of mean spillover β_4 are significant from WTI to China and Brazil irrespective of Pakistan because there is no spillover from the oil market to Pakistan equity market. Shocks in the oil market are only transmitted to the China equity market and Brazil equity market. Only in case of Pakistan fluctuation in the oil market has no relationship with the Pakistan stock returns. The results of GJR GARCH, γ_3 is positively significant for the equity markets like Pakistan and Brazil which gives us the indication of asymmetric behavior in these equity markets.

We can say any bad news like COVID-19 or any other pandemic has the ability to create more volatility in these markets as compared to good news. In case of China, there is no asymmetric behavior. So either there is a good news or bad news, it will have same effect on China stock market. The parameter of COVID intercept β_5 has insignificant results for all the three equity markets which mean there is no contradiction in the returns during the COVID period and before COVID period. We can say that China stock returns, Brazil stock returns and Pakistan stock returns have not changed due to the COVID-19 pandemic.

Another interesting scenario in the results is that the parameters of COVID slope β_6, is significant in case of Pakistan and China. It means that there exists the returns spillover in between the oil market and Pakistan stock market. Before the COVID-19 pandemic there is no spillover from WTI to Pakistan but after the news of COVID-19 pandemic, shocks are transmitted from the oil market to Pakistan equity market which proves the impact of COVID-19 is there in case of

Pakistan. Moreover positive sign is the indication that spillover is high in China and Pakistan during the COVID period. The results of Brazil stock market is insignificant which shows that mean spillover is same as before during the COVID period. Simply we can say that returns spillover during the COVID period is only different in case of Pakistan stock market and China equity market while there is no COVID impact on returns spillover of Brazil equity market. Shocks in returns of the oil market during the COVID-19 pandemic are not transmitted to the returns of Brazil equity market.

4.4 Volatility Spillover from WTI to Equity Market during the COVID Period

The second objective of the study is to investigate about the volatility spillover from the oil market (WTI) to the equity markets of emerging and developed countries during the COVID-19 pandemic by using an econometric model.

Table 4.7 shows the parameters of volatility spillover during the COVID period by ARMA (1, 1)-GJR-GARCH (1, 1)-M model. A COVID dummy is used to find the impact on volatility and its spillover from the oil market to the equity market. The coefficients of GJR GARCH are explained previously in the section of mean spillover from the oil market to equity market. Similarly the coefficients of all these equity markets i.e. AR term, MA term, GARCH in mean, ARCH term and GARCH term are discussed later in the section of mean spillover from equity market to the oil market during the COVID-19 pandemic.

Here we discuss only the volatility spillover γ_4 and the intercept γ_5 and slope dummy γ_6. For equity markets of US (NASDAQ100) and some emerging markets i.e. Brazil (BOVESPA), Russia (RTSI), India (BSE500) and Pakistan (KSE100), the results of volatility spillover γ_4 are significant and positive. It means that volatility in the WTI transmit to these equity markets. Positive sign proves that if volatility is high in the oil market, the equity market volatility is also be high because it is moving in the same direction with the WTI. Now if we look at the

TABLE 4.7: Volatility Spillover from Oil market to Equity Market during the COVID-19 crisis - ARMA-GJR GARCH-M Model

	WTI	**NASDAQ100**	**BOVESPA**	**RTSI**	**BSE500**	**KSE100**
β_0	**-0.0033**	0.0002	-0.0016	-0.0014	-0.0005	0.001
	(0.0013)	(0.7742)	(0.1756)	(0.0965)	(0.3827)	(0.1123)
β_1	**0.3554**	-0.0376	0.014	0.3556	0.2586	0.2142
	(0.3019)	(0.6252)	(0.8107)	(0.0000)	(0.0033)	(0.0409)
β_2	**-0.3783**	0.0039	-0.0438	-0.3595	-0.159	-0.0286
	(0.2678)	(0.9611)	(0.4664)	(0.0000)	(0.0822)	(0.7884)
β_3	**0.1671**	0.0385	0.0999	0.0582	0.0793	-0.0607
	(0.0020)	(0.5212)	(0.2790)	(0.3253)	(0.2905)	(0.4130)
β_4	-	0.0023	0.0042	0.005	0.0012	-6.63E
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.9658)
γ_0	**7.11E-06**	2.21E-06	6.71E-06	4.97E-07	3.87E-06	4.86E-06
	(0.0000)	(0.0004)	(0.0001)	(0.6463)	(0.0000)	(0.0000)
γ_1	**0.1061**	-0.0183	0.0379	0.0176	-0.0087	0.0071
	(0.0000)	(0.0224)	(0.0004)	(0.0034)	(0.2669)	(0.4300)
γ_2	**0.8872**	0.8284	0.8542	0.9059	0.8514	0.811
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_3	-	0.2188	0.0768	0.0886	0.1718	0.2427
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_4	-	5.08E-06	5.27E-06	6.90E-06	1.74E-06	9.87E-07
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0408)
γ_5	-	3.36E-06	2.54E-06	-6.40E-06	2.45E-07	-3.02E-06
	-	(0.7208)	(0.7284)	(0.0926)	(0.8915)	(0.2472)
γ_6	-	2.71E-05	1.20E-05	1.13E-05	7.33E-06	7.88E-06
	-	(0.0301)	(0.0559)	(0.0278)	(0.0063)	(0.0413)

Where WTI = crude Oil Market, NASDAQ100 = US stock index, BOVESPA = Brazil equity market, BSE500 = India stock market, RTSI = Russian index, KSE100 = Pakistan equity index, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, γ_3 denotes the parameter of GJR-GARCH, γ_4 denotes the parameter of volatility spillover, γ_5 denotes the parameter of COVID intercept with volatility and γ_6 denotes the parameter of COVID slope with volatility spillover

coefficients of COVID intercept γ_5, it is insignificant for all the equity markets which mean that the COVID period volatility has no relationship with the normal period volatility for these equity markets. It concludes that upon the news of COVID-19, the volatility of equity market is same as volatility without the COVID-19 pandemic. The normal period volatility of financial markets like US, Brazil, India, Pakistan and Russia has no relationship with the COVID period volatility which means that volatility in the normal period and volatility during the COVID-19 pandemic are same for these markets.

The parameter of COVID slope γ_6 is positively significant for all the equity markets indicating that volatility spillover is different during the COVID period as compared to volatility spillover in normal period. The positive sign shows that volatility spillover from the oil market to US, Brazil, India, Pakistan and Russia is high during the COVID period. The point to be noted is the COVID-19 pandemic has a significantly high impact on the financial markets because it has greatly influenced the oil market volatility which is translated to the volatility of the financial markets. So the financial markets of Pakistan (KSE100), India (BSE500), Russia (RTSI), Brazil (BOVESPA) and US (NASDAQ100) are very sensitive to the COVID-19 pandemic. Moreover we have seen a record number of affected cases especially in the US and India. So volatility transmission from the oil market to these equity markets is closely connected to the COVID-19 pandemic.

Table 4.8 shows the parameters of volatility spillover during the COVID period in countries like Japan, South Africa, China, UK and France. ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used for volatility modeling. COVID dummy is used to determine the volatility spillover between the COVID period and normal period. The parameter of ARCH term, GARCH term for equity markets are discussed later in the section of volatility spillover from the equity market to the oil market during the COVID-19 pandemic.

For now we will look at the volatility spillover from the oil market (WTI) to equity market. The results of volatility spillover γ_3 show significant results from WTI to Japan equity market (TOPIX1000), South Africa stock market (SA40), UK equity index (FTSE100) and French financial market (CAC) while in case of

TABLE 4.8: Volatility Spillover from the Oil market to Equity Market during the COVID-19 pandemic - ARMA GARCH-M Model

	WTI	**TOPIX1000**	**SA40**	**SZSE**	**FTSE100**	**CAC**
β_0	**-0.0033**	-0.0004	-0.0014	-0.0008	-0.0017	-0.0008
	(0.0013)	(0.3105)	(0.0037)	(0.2687)	(0.0006)	(0.0864)
β_1	**0.3554**	0.6787	0.3186	0.5054	0.2144	0.2029
	(0.3019)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0052)
β_2	**-0.3784**	-0.6803	-0.3775	-0.5101	-0.2297	-0.2024
	(0.2678)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0082)
β_3	**0.1671**	0.044905	0.1528	0.0491	0.2091	0.1111
	(0.0020)	(0.2247)	(0.0043)	(0.3622)	(0.0011)	(0.0395)
β_4	-	0.001024	0.0025	0.0014	0.0025	0.0023
	-	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_0	**7.11E-06**	3.28E-06	-3.12E-07	2.05E-06	2.13E-06	3.66E-07
	(0.0000)	(0.0004)	(0.6263)	(0.0088)	(0.0002)	(0.5470)
γ_1	**0.1061**	0.1136	0.0643	0.0447	0.1079	0.1057
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_2	**0.8872**	0.8464	0.8906	0.9455	0.8179	0.8509
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
γ_3	-	2.43E-06	4.77E-06	4.39E-07	3.25E-06	4.34E-06
	-	(0.0008)	(0.0000)	(0.5028)	(0.0000)	(0.0000)
γ_4	-	-4.77E-07	-2.63E-06	2.91E-06	-	-
	-	(0.8928)	(0.4451)	(0.1047)	-	-
γ_5	-	3.11E-06	9.17E-06	-2.57E-06	1.24E-05	8.11E-06
	-	(0.3451)	(0.0063)	(0.0340)	(0.0003)	(0.0005)

Where WTI =Crude oil market, TOPIX1000 = Japan equity index, SA40 = South Africa stock index, SZSE = China equity index, FTSE100 = UK equity index, CAC = France stock index, values in the parenthesis denotes the P-value. β_4 *denotes the parameter of mean spillover,* γ_3 *denotes the parameter of volatility spillover,* γ_4 *denotes the parameter of COVID intercept with volatility and* γ_5 *denotes the parameter of COVID slope with volatility spillover*

WTI to Chinese equity market (SZSE) there is no volatility spillover. Volatility fluctuation in the oil market is transmitted to the volatility of these equity markets except Chinese equity index. The positive sign provide the indication that higher volatility in the oil market results in higher volatility in these financial markets because of same direction.

Now the purpose of the study is to see the difference between the COVID period volatility and normal period volatility in these equity markets. All these equity markets have the same volatility during both periods because the results of COVID intercept γ_4 are insignificant. The inclusion of COVID period made no difference in the volatility of all these equity markets. However volatility spillover has made a difference during the COVID-19 pandemic. If we look at the results of COVID slope γ_5, some values are highly significant except Japan which gives us the confidence that there is a big difference of volatility spillover during the COVID period and normal period. So we can say that from WTI to France, WTI to China, WTI to South Africa and WTI to UK, the volatility spillover is high during the COVID-19 pandemic.

Here is an interesting phenomenon about the Chinese equity market. At first there is no spillover from the oil market to China equity market but then volatility spillover occurs during the COVID period with a negative sign indicating that spillover is low during the COVID-19 pandemic. High volatility spillover is recorded in equity markets like South Africa, UK and France because the sign of coefficient is positive for these markets. Japan equity market has also some contradictory results. The impact of COVID-19 on volatility spillover from WTI to Japan is proved insignificant which means that volatility spillover is same during the COVID period and normal period. Simply we can say that Japan equity market volatility has not reacted to the news of COVID-19 and it is same as before throughout the COVID period.

The COVID-19 pandemic when got the center of attention in equity markets of China, France, South Africa and UK has a significantly high impact on these equity markets. The COVID-19 pandemic has produced some big shocks which results in higher volatility in the oil market and that higher volatility is transmitted to the

volatility of these equity markets due to which the cash flows of these markets are severely affected. Normally in case of China equity market the oil market shocks are not transmitted to the equity market but the fear caused by the COVID-19 pandemic has made the China equity market impulsive and so it is responded to the shocks created by the COVID-19 pandemic in the oil market.

Higher volatility by the COVID-19 pandemic in the oil market is responded by low volatility in the China financial market. Japan has a different scenario in this case. Simply Japan equity market volatility is not responded to the COVID-19 pandemic. Oil markets shocks do not have the ability to affect the volatility of Japan equity market. Other markets i.e. France, South Africa and UK are very much responsive to the COVID-19 pandemic. Positively significant results provide the evidence that due to the COVID-19 pandemic, higher oil market volatility results in the higher volatility for these equity markets. So it is confirmed that the COVID-19 pandemic have got a very close connection to the oil market and equity market link.

Table 4.9 shows the measure of volatility spillover from WTI to two developed markets i.e. Germany and Italy during the event of COVID-19 pandemic through the process of ARMA (1, 1)-GARCH (1, 1)-M model. These two developed markets are affected badly due to the COVID-19 pandemic and they have highest number of cases recorded within two months period. All results are significant for these two markets which is justified that they are most affected by the COVID-19 pandemic. The parameter of volatility spillover γ_3 is significant and positive from WTI to Germany equity market (DAX) and Italy stock index (ITALY50). It means that variation in the volatility of oil market will be shifted to the volatility of Germany stock index and Italian stock index. The sign is positive which shows the same direction. Low volatility in the oil market causes low volatility in these equity markets while higher volatility causes higher volatility in these indices.

The results of COVID intercept γ_4 are also significant but negative for both developed markets. It means that the COVID period has low volatility as compared to normal period volatility. There is a change in the both periods volatility. News of the COVID-19 pandemic has affected the volatility of Italy equity market and

TABLE 4.9: Volatility Spillover from the Oil market to Equity Market during the COVID-19 period - ARMA-GARCH-M Model

	WTI	**DAX**	**ITALY50**
β_0	**-0.0033**	-0.0011	-0.0018
	(0.0013)	(0.1212)	(0.0215)
β_1	**0.3555**	0.1703	0.1342
	(0.3019)	(0.0197)	(0.0566)
β_2	**-0.3783**	-0.17	-0.1812
	(0.2678)	(0.0258)	(0.0128)
β_3	**0.1671**	0.1163	0.1361
	(0.0020)	(0.0761)	(0.0301)
β_4	-	0.0026	0.0033
	-	(0.0000)	(0.0000)
γ_0	**7.11E-06**	-1.23E-07	2.13E-06
	(0.0000)	(0.8542)	(0.1007)
γ_1	**0.1061**	0.0678	0.0872
	(0.0000)	(0.0000)	(0.0000)
γ_2	**0.8872**	0.8959	0.88
	(0.0000)	(0.0000)	(0.0000)
γ_3	-	4.56E-06	4.67E-06
	-	(0.0000)	(0.0001)
γ_4	-	-6.69E-06	-8.97E-06
	-	(0.0416)	(0.0243)
γ_5	-	1.43E-05	1.50E-05
	-	(0.0002)	(0.0002)

Where DAX = Germany stock index, ITALY50 = Italy stock index, WTI = crude oil market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, γ_3 denotes the parameter of volatility spillover, γ_4 denotes the parameter of COVID intercept with volatility and γ_5 denotes the parameter of COVID slope with volatility spillover

Germany financial market. Similarly the COVID-19 pandemic has also an impact on the volatility spillover from WTI to Germany and Italy. If we look at the results of COVID slope γ_5, it is significant for both countries. So we can say that volatility spillover from WTI to Italy and Germany is different during the COVID period. Positive sign is the indication that volatility spillover is high during the COVID-19 pandemic. The global COVID-19 lockdown has done the damage to the oil market due to which volatility of the crude oil market (WTI) increases which in turn increases the volatility of Germany and Italy financial markets. These two markets are more volatile during the COVID-19 pandemic.

4.5 Mean Spillover from Equity Market to the Oil market during the COVID-19 Pandemic

The third objective of the study is to determine mean spillover from developed and emerging countries equity markets to the oil market (WTI) during the COVID-19 pandemic by using econometric model.

Table 4.10 shows the measure of mean spillover from the equity market to the oil market (WTI) during the COVID-19 period. Equity markets include some of the emerging markets i.e. India, South Africa, Brazil and Pakistan. ARMA (1, 1)-GARCH (1, 1)-M model is used. Moreover a dummy variable named COVID is also used as an intercept and slope dummy to find the impact of the COVID-19 pandemic on the oil market returns along with mean spillover from the equity market to the oil market. Both intercept and slope dummy are used independently in the equation and also in combination with both mean and volatility spillover. The best model is selected on the basis of lowest Akaike Information Criteria (AIC). Coefficients of all lagged terms and ARCH GARCH terms are reported with their p-value (in parenthesis). At first we interpret the coefficients of equity markets and their impact on the oil market through mean and volatility spillover.

The coefficient of Autoregressive term, β_1 is insignificant for India stock exchange (BSE500), Pakistan stock exchange (KSE100) and Brazil stock exchange

TABLE 4.10: Mean Spillover from Equity Markets to the Oil market during the COVID-19 period - ARMA-GARCH-M Model

	BSE500	**WTI**	**KSE100**	**WTI**	**BOVESPA**	**WTI**	**SA40**	**WTI**
β_0	**-0.0007**	-0.0448	**4.04E-05**	-0.0027	**-0.0009**	-0.0027	**-2.97E-05**	-0.0037
	(0.3302)	(0.0000)	**(0.9546)**	(0.0095)	**(0.4498)**	(0.0038)	**(0.6709)**	(0.0003)
β_1	**0.2335**	-0.0589	**0.0957**	0.1233	**0.1434**	0.1363	**0.9458**	0.2229
	(0.1842)	(0.7381)	**(0.4242)**	(0.7266)	**(0.7435)**	(0.0260)	**(0.0000)**	(0.0003)
β_2	**-0.1533**	-0.0057	**0.0737**	-0.1448	**-0.1701**	-0.1804	**-0.9651**	-0.2928
	(0.3958)	(0.9759)	**(0.5380)**	(0.6815)	**(0.6975)**	(0.0043)	**(0.0000)**	(0.0000)
β_3	**0.1369**	1.4967	**0.1164**	0.1597	**0.0963**	0.1605	**0.0058**	0.167
	(0.0821)	(0.0000)	**(0.1559)**	(0.0029)	**(0.3361)**	(0.0027)	**(0.4832)**	(0.0016)
β_4	-	0.0023	-	-0.0005	-	0.0052	-	0.0045
	-	(0.0589)	-	(0.1287)	-	(0.0000)	-	(0.0000)
β_5	-	-0.009494	-	0.0006	-	-	-	-
	-	(0.0539)	-	(0.7236)	-	-	-	-
β_6	-	0.0105	-	0.0028	-	0.0039	-	0.0037
	-	(0.0001)	-	(0.0157)	-	(0.0074)	-	(0.0369)
γ_0	**3.58E-06**	0.0007	**5.43E-06**	2.08E-07	**9.55E-06**	-2.53E-06	**2.79E-06**	-1.83E-06
	(0.0000)	(0.0000)	**(0.0000)**	(0.8883)	**(0.0000)**	(0.1273)	**(0.0000)**	(0.2525)
γ_1	**0.0962**	0.1489	**0.1383**	0.1058	**0.0808**	0.0867	**0.0836**	0.0934
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_2	**0.8679**	0.5862	**0.8085**	0.8822	**0.8733**	0.8972	**0.8932**	0.8884
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	-3.72E-05	-	8.80E-06	-	1.14E-05	-	1.17E-05
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)

Where BSE500 = India stock exchange, KSE100 = Pakistan Equity index, BOVESPA = Brazil stock market, SA40 = South Africa stock exchange, WTI = crude oil market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept, β_6 denotes the parameter of COVID slope with mean spillover and γ_3 denotes the parameter of volatility spillover

(BOVESPA) which means the current day returns cannot be predicted through past day returns for the aforementioned equity markets while for South Africa equity market (SA40), it is significant positively which reveals the current day returns of this market can be predicted from past day returns. So we conclude that the equity markets of India, Pakistan and Brazil are efficient while the South Africa stock market is inefficient due its predictability from past returns.

The coefficient of moving average term, β_2 is also significant and negative for South Africa stock market which means the current day returns can be predicted from past shocks. We can also say that past abnormal movement can negatively translate in today returns while for the rest of equity markets i.e. Pakistan, India and Brazil, this relationship is insignificant which provide the evidence that these markets did not account for the process of correction on the basis of past shocks.

The coefficient of GARCH in mean, β_3 is insignificant for all the equity markets which indicate that the current day returns cannot be predicted through forecasted volatility in equity markets of Pakistan, India, South Africa and Brazil. The parameter of mean spillover β_4 shows a significant positive impact from the equity markets of India, South Africa and Brazil to the crude oil market (WTI) which implies that variation in these markets affect the oil market returns in the same direction. It suggests that if returns of any of these markets are changed, the oil market returns are respond to it in the same way. In case of Pakistan to WTI there is no mean spillover which means any change in Pakistan equity market returns does not affect the oil market returns.

If we look at the equity market to oil market spillover, the values of COVID intercept β_5 is insignificant in all cases revealing that there is not a big difference during the COVID period returns and normal period returns in the oil market. The parameter of COVID slope β_6 is significant and positive from all the equity markets to the oil market, which provides the evidence that mean spillover is different during the COVID period as compared to the normal period. Mean spillover from the equity markets of India, Brazil, Pakistan and South Africa to WTI is high during the COVID period because the sign is positive. An interesting phenomenon reveals that there is no mean spillover from Pakistan to WTI but

there is a returns spillover during the COVID period confirming the fact that the oil market returns are reactive to shocks created by the COVID-19 pandemic in the Pakistan equity return and also in India equity returns, Brazil equity returns and South Africa equity returns.

Table 4.11 shows the parameter of mean spillover from some of the developed countries equity markets to WTI and also from two emerging equity markets to WTI during the COVID period. ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used. The best model is selected on the basis of lowest Akaike Information Criteria (AIC). In this case GJR GARCH models have lowest AIC as compared to all other models so that is selected as best possible model. The coefficient of Autoregressive term, β_1 is significant for China (SZSE) and Japan (TOPIX1000) which means it is possible to forecast the current day returns of China and Japan equity market through past day returns indicating that both markets are not efficient. It also implies that both China and Japan markets are not suitable for the portfolio diversification.

The results of β_1 are insignificant for some developed countries like Russia (RTSI), US (NASDAQ100) and UK (FTSE100) which ensure the efficiency of these markets. We can also say that through past returns, it is not possible for these markets to predict today returns. The coefficient of MA term, β_2 is found to be significant for Japan and China which indicates that the past economic shocks are translated in today returns for the following markets. The sign is negative for Japan which means, if past abnormal movements are high, the current day returns will be low and if past shocks are high/low, the response will be same in case of China because the sign is positive. So we can say past shocks influences the current day returns for Japan and China.

If we look at the other developed countries like US, UK and Russia, the results are insignificant which suggest that today returns has no relationship with past economic shocks. These markets did not make adjustment to the next day on the basis of past shocks. The coefficient of GARCH in mean, β_3 is insignificant for all the developed equity markets like US, UK, Japan and also for two emerging markets Russia and China which implies that forecasted volatility cannot be used

TABLE 4.11: Mean Spillover from Equity Markets to the Oil market during the COVID-19 pandemic - ARMA-GJR-GARCH-M Model

	RTSI	**WTI**	**SZSE**	**WTI**	**NASDAQ100**	**WTI**	**FTSE100**	**WTI**	**TOPIX1000**	**WTI**
β_0	**0.0004**	-0.0026	**-0.0004**	-0.0018	**-7.39E-05**	-0.0021	**-0.0009**	-0.0021	**-0.0001**	-0.0024
	(0.7128)	(0.0060)	**(0.6832)**	(0.0602)	**(0.8862)**	(0.0157)	**(0.0383)**	(0.0156)	**(0.7356)**	(0.0121)
β_1	**0.1325**	0.0563	**-0.8174**	0.3289	**0.0663**	0.0027	**0.269**	0.0209	**0.7259**	0.1651
	(0.6656)	(0.2988)	**(0.0000)**	(0.0345)	**(0.8522)**	(0.9678)	**(0.8022)**	(0.7043)	**(0.0021)**	(0.3967)
β_2	**-0.071**	-0.1392	**0.8458**	-0.3663	**-0.1112**	-0.0308	**-0.2708**	-0.0725	**-0.7176**	-0.2078
	(0.8156)	(0.0127)	**(0.0000)**	(0.0171)	**(0.7528)**	(0.6511)	**(0.8014)**	(0.1965)	**(0.0029)**	(0.2812)
β_3	**0.0073**	0.1454	**0.0448**	0.0846	**0.1153**	0.1208	**0.1514**	0.1082	**0.028**	0.1129
	(0.9164)	(0.0098)	**(0.6165)**	(0.0797)	**(0.0825)**	(0.0222)	**(0.1601)**	(0.0458)	**(0.4433)**	(0.0285)
β_4	-	0.0062	-	0.0015	-	0.0048	-	0.0054	-	0.0014
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)
β_5	-	0.0014	-	0.00033	-	-0.0005	-	0.0018	-	0.0005
	-	(0.3723)	-	(0.7906)	-	(0.8042)	-	(0.2890)	-	(0.7337)
β_6	-	0.0019	-	0.0009	-	0.0021	-	0.0029	-	0.0014
	-	(0.2156)	-	(0.6556)	-	(0.2137)	-	(0.1051)	-	(0.4542)
γ_0	**5.68E-06**	7.15E-06	**2.53E-06**	5.02E-06	**5.44E-06**	2.33E-06	**3.59E-06**	2.38E-06	**5.50E-06**	7.98E-06
	(0.0000)	(0.0001)	**(0.0000)**	(0.0023)	**(0.0000)**	(0.0788)	**(0.0000)**	(0.1737)	**(0.0000)**	(0.0000)
γ_1	**0.0772**	0.025	**0.0452**	0.0193	**0.1434**	0.0248	**0.1366**	0.0324	**0.1242**	0.0218
	(0.0000)	(0.0013)	**(0.0000)**	(0.0044)	**(0.0000)**	(0.0024)	**(0.0000)**	(0.0001)	**(0.0000)**	(0.0026)
γ_2	**0.9052**	0.8761	**0.9448**	0.9023	**0.8179**	0.8877	**0.8278**	0.8844	**0.8412**	0.896
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	0.1285	-	0.1232	-	0.1259	-	0.1147	-	0.1282
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_4	-	6.86E-06	-	2.88E-06	-	8.59E-06	-	8.77E-06	-	6.06E-07
	-	(0.0000)	-	(0.0167)	-	(0.0000)	-	(0.0000)	-	(0.6666)

Where RTSI = Russia security market, SZSE = China stock market, NASDAQ100 = US Equity market, FTSE100 = UK Equity market, TOPIX1000 = Japan stock exchange WTI = crude oil market, values in the parenthesis denotes the P-value., β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept and 6 denotes the parameter of COVID slope with mean spillover, γ_3 denotes the parameter of GJR-GRACH and γ_4 denotes the parameter of volatility spillover

to predict the current day returns. The parameter of mean spillover, β_4 is significant from the equity market to the oil market (WTI) and positive for both developed and emerging markets indicating that mean spillover is present from US to WTI, UK to WTI, Japan to WTI, Russia to WTI and China to WTI. If the following markets returns are changed or if there is some variation in these markets, the oil market returns will also be influenced. The positive sign shows that these markets are moving in the same direction with the oil market. Higher returns in these equity markets will result in higher returns for WTI. By looking at spillover from the equity market to the oil market, the values of COVID intercept β_5 is insignificant for the oil market which provide the evidence that returns of the oil market are same for both COVID period and non-COVID period.

Results conclude that there is no difference in between the COVID period returns and normal period returns. Similarly the results of β_6, is insignificant from all the equity markets to the oil market indicating that mean spillover is same during the COVID period as well. We can also say that COVID period does not affect the mean spillover from stock market to the oil market. The COVID-19 pandemic does not influence oil market returns from shocks that are created in the equity markets of US, UK, Japan, Russia and China. So in simple words shocks created by the COVID-19 pandemic in these equity markets has no relationship with the oil market returns.

Table 4.12 recognizes the measure of mean spillover during the COVID period from equity market to the oil market by ARMA (1, 1)-GJR-GARCH (1, 1)-M model. Remaining Equity markets include three developed countries i.e. Germany (DAX), Italy (ITALY40) and France (CAC). These are the countries affected the most by COVID-19 pandemic. The coefficient of AR term, β_1 is insignificant in all equity markets showing that there exists no relationship between past returns and today returns.

We can also say that in the equity markets like France, Germany and Italy, prediction of today returns is not possible on the basis of past returns. The coefficient of MA term, β_2 is also insignificant for France, Germany and Italy financial markets indicating that past abnormal movement does not influence the current

TABLE 4.12: Mean Spillover from Equity Markets to the Oil market during the COVID-19 crisis - ARMA-GJR-GARCH-M Model

	DAX	**WTI**	**ITALY50**	**WTI**	**CAC**	**WTI**
β_0	**-0.0005**	-0.0016	**-0.0011**	-0.0021	**-0.0003**	-0.0012
	(0.4297)	(0.0791)	**(0.1645)**	(0.0200)	**(0.7046)**	(0.1775)
β_1	**0.1335**	0.0374	**0.2376**	-0.0485	**0.1058**	0.0408
	(0.6626)	(0.5827)	**(0.5188)**	(0.4585)	**(0.9047)**	(0.5301)
β_2	**-0.1283**	-0.0773	**-0.2783**	0.0098	**-0.0897**	-0.0857
	(0.6765)	(0.2633)	**(0.4453)**	(0.8836)	**(0.9194)**	(0.1915)
β_3	**0.1068**	0.0888	**0.1047**	0.1143	**0.0951**	0.0749
	(0.1017)	(0.0988)	**(0.1046)**	(0.0414)	**(0.1354)**	(0.1645)
β_4	-	0.00426	-	0.0042	-	0.0045
	-	(0.0000)	-	(0.0000)	-	(0.0000)
β_5	-	0.0007	-	0.0006	-	0.0009
	-	(0.7060)	-	(0.7410)	-	(0.6038)
β_6	-	0.0048	-	0.0067	-	0.0038
	-	(0.0042)	-	(0.0000)	-	(0.0095)
γ_0	**3.01E-06**	1.93E-06	**5.02E-06**	5.26E-06	**3.20E-06**	1.97E-06
	(0.0000)	(0.2548)	**(0.0000)**	(0.0038)	**(0.0000)**	(0.2519)
γ_1	**0.089**	0.0298	**0.0961**	0.0289	**0.1346**	0.0308
	(0.0000)	(0.0001)	**(0.0000)**	(0.0004)	**(0.0000)**	(0.0002)
γ_2	**0.8921**	0.8874	**0.8854**	0.8859	**0.8463**	0.8873
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	0.118	-	0.1219	-	0.1198
	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_4	-	8.94E-06	-	5.48E-06	-	8.32E-06
	-	(0.0000)	-	(0.0000)	-	(0.0000)

Where DAX = German Equity market, CAC = France stock market WTI = crude oil market, values in the parenthesis denotes the P-value, β_4 denotes the parameter of mean spillover, β_5 denotes the parameter of COVID intercept , β_6 denotes the parameter of COVID slope with mean spillover, γ_3 denotes the parameter of GJR-GRACH and γ_4 denotes the parameter of volatility spillover.

day returns. Today returns cannot be forecasted by previous day shocks. The coefficient of GARCH in mean, β_3 is also insignificant for all the three equity markets which clearly indicate that forecasted volatility is not useful for the prediction of today returns for the equity markets of Germany, France and Italy.

The coefficient of mean spillover, β_4 is significant from all the equity markets to WTI which means that any change in the equity returns of Italy, France and Germany will transmit into the oil market returns. Variation in the returns of the equity markets will transmit to the oil market. During spillover from the equity markets to the oil market, the parameter of COVID interceptβ_5 is insignificant in all, suggesting that there is no big difference in returns of WTI during the COVID-19 pandemic and before the COVID-19 pandemic. There is no contradiction in the returns of oil market before the COVID period and during the COVID period.

The coefficient of β_6 is significant from all the three developed equity markets to WTI which confirms that there is a difference of mean spillover during the COVID period and before the COVID period. We can say that mean spillover from these equity markets to the oil market is different during the COVID period. Sign is positive for the returns spillover from all the three equity markets to the oil market which implies that mean spillover of the COVID period is high as compared to normal period.

It conclude that when the equity market returns have got the shocks from the news of COVID pandemic, it is transmitted highly to the returns of oil market (WTI) confirming that the oil market has responded extremely to the COVID-19 pandemic. When the economic activity is decreased in these countries, the oil market demand also decreased due to which oil prices fluctuated regularly.

4.6 Volatility Spillover from Equity Market to Oil market during the COVID Period

The fourth objective of the study is to investigate about volatility spillover from developed and emerging countries equity markets to the oil market (WTI) during

the COVID-19 pandemic through an econometric model. Table 4.13 presents the measure of volatility spillover from the equity markets of India, Pakistan, Brazil and South Africa to WTI during the COVID period. ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used to determine the impact of COVID-19 pandemic on the volatility of the oil market. The coefficients of mean equation are discussed for all the equity markets in the section of mean spillover from equity market to the oil market during the COVID-19 pandemic.

The parameters of volatility equation are discussed here. The coefficient of ARCH term, γ_1 is significant for all the equity markets which means past price behavior influences current volatility. We can also say that current volatility can be predicted through past prices movement in equity markets of India (BSE500), Pakistan (KSE100), Brazil (BOVESPA) and South Africa (SA40). The coefficient of GARCH term, γ_2 is also significant for all the equity markets that mentioned above which reveals that there is persistent of volatility in all these equity markets. Volatility in the past can be used to predict the current volatility. The sum of coefficients of γ_1 and γ_2 are closer to 1 for equity markets of India, Pakistan, South Africa and Brazil which means persistence of volatility is long run in nature for these equity markets. If we look at the coefficient of GJR GARCH γ_3, the asymmetric behavior exists for WTI oil market. The sign is positive so it means that bad news like the COVID-19 pandemic creates more volatility in oil market.

The parameter of volatility spillover, γ_4 is significant from all the equity markets to WTI which means volatility spillover exist between Brazil equity market and WTI, Pakistan stock market and WTI, India financial market and WTI and South Africa stock index to WTI but it shows a negative sign from India to WTI which means volatility in India equity market negatively translates into the oil market while for the rest of the countries volatility is positively translates into the oil market. We can also explain that if volatility increases in one equity market, the oil market volatility will also increases except Indian equity market to WTI because it shows opposite direction. By looking at the volatility spillover from these equity markets to the oil market, the coefficient of COVID intercept γ_5 is significant for all, indicating that the COVID period volatility of the oil market

TABLE 4.13: Volatility Spillover from Equity Markets to Oil market during the COVID-19 period - ARMA-GJR GARCH-M Model

	BSE500	**WTI**	**KSE100**	**WTI**	**BOVESPA**	**WTI**	**SA40**	**WTI**
β_0	**-0.0006**	-0.0379	**4.04E-05**	-0.0017	**-0.0009**	-0.0022	**-2.97E-05**	-0.0029
	(0.3302)	(0.0001)	**(0.9546)**	(0.0727)	**(0.4498)**	(0.0159)	**(0.6709)**	(0.0027)
β_1	**0.2336**	-0.0532	**0.0957**	0.3269	**0.1434**	0.1221	**0.9458**	0.1875
	(0.1842)	(0.8642)	**(0.4242)**	(0.2328)	**(0.7435)**	(0.0506)	**(0.0000)**	(0.0054)
β_2	**-0.1533**	-0.0027	**0.0737**	-0.3487	**-0.1701**	-0.1657	**-0.9651**	-0.2572
	(0.3958)	(0.9933)	**(0.5380)**	(0.2007)	**(0.6975)**	(0.0100)	**(0.0000)**	(0.0001)
β_3	**0.1369**	1.1843	**0.1164**	0.08144	**0.0964**	0.1162	**0.0058**	0.1221
	(0.0821)	(0.0000)	**(0.1559)**	(0.1118)	**(0.3361)**	(0.0283)	**(0.4832)**	(0.0225)
β_4	-	0.0027	-	-0.0005	-	0.0051	-	0.0044
	-	(0.0268)	-	(0.0857)	-	(0.0000)	-	(0.0000)
γ_0	**3.58E-06**	0.0007	**5.43E-06**	1.98E-06	**9.55E-06**	1.37E-06	**2.79E-06**	1.86E-08
	(0.0000)	(0.0000)	**(0.0000)**	(0.1781)	**(0.0000)**	(0.4404)	**(0.0000)**	(0.9911)
γ_1	**0.0962**	0.1505	**0.1383**	0.0189	**0.0808**	0.0222	**0.0837**	0.0225
	(0.0000)	(0.0000)	**(0.0000)**	(0.0068)	**(0.0000)**	(0.0008)	**(0.0000)**	(0.0006)
γ_2	**0.8679**	0.5887	**0.8085**	0.9059	**0.8733**	0.9095	**0.8932**	0.9153
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	-	-	0.1056	-	0.0899	-	0.0815
	-	-	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_4	-	-3.49E-05	-	6.57E-06	-	7.31E-06	-	7.83E-06
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_5	-	-0.0003	-	-0.0001	-	-5.18E-05	-	-6.56E-05
	-	(0.0012)	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_6	-	0.0001	-	0.0001	-	6.28E-05	-	7.26E-05
	-	(0.0016)	-	(0.0000)	-	(0.0000)	-	(0.0000)

Where BSE500 = India stock exchange, KSE100 = Pakistan Equity index, BOVESPA = Brazil stock market, SA40 = South Africa stock exchange, WTI = crude Oil market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, γ_3 denotes the parameter of GJR-GARCH, γ_4 denotes the parameter of volatility spillover, γ_5 denotes the parameter of COVID intercept with volatility and γ_6 denotes the parameter of COVID slope with volatility spillover

is different as compared to normal period volatility. Sign is negative which means volatility is low in the oil market during the COVID-19 pandemic as compared to volatility before the COVID-19 pandemic.

The coefficient of γ_6 is significant which means volatility spillover is different in Brazil, Pakistan, India and South Africa equity market to the oil market during the COVID-19 pandemic. The sign is positive for all the regions which imply that volatility spillover from equity markets to WTI is high during the COVID period. So it provide the evidence that higher volatility in these equity markets caused by the COVID-19 pandemic is followed by higher volatility in the oil market indicating that the oil market volatility is influenced by the COVID-19 pandemic. India is still the hotspot of the COVID-19 pandemic with second most number of recorded cases in the world. Pakistan, Brazil and South Africa are also affected by the strict lockdown policies and high mortality rates. So the point here to justify is that the fear caused by the COVID-19 pandemic has affected the economic indicators of the country and that fear is transmitted to the oil market as well which confirms that the COVID-19 pandemic has severely affected these countries in terms of equity market and the oil market link.

Table 4.14 shows the estimates of volatility spillovers from equity markets like Russia to WTI, China to WTI, Japan to WTI, US to WTI and UK to WTI. Model used is ARMA (1, 1)-GJR-GARCH (1, 1)-M model. The ARCH term, γ_1 show significant results for all the equity markets. It means in financial markets like Russia (RTSI), China (SZSE) US (NASDAQ100), UK (FTSE100) and Japan (TOPIX1000), the current volatility can be forecasted through past price behavior. The GARCH term, γ_2 is also significant for all the equity markets which give us the confidence about the persistence of volatility in these markets. The sum of coefficients of γ_1 and γ_2 is closer to 1 for some of these developed and emerging markets indicating that volatility persistence is longer in run.

If we look at the coefficient of GJR GARCH γ_3, the asymmetric behavior exists for the oil market (WTI). The sign is positive so it means that bad news like the COVID-19 pandemic creates more volatility in the oil market. The results of volatility spillover γ_4 from all the equity markets are positively significant to the

TABLE 4.14: Volatility Spillover from Equity Markets to the Oil market during the COVID-19 pandemic - ARMA-GJR-GARCH-M Model

	RTSI	**WTI**	**SZSE**	**WTI**	**NASDAQ100**	**WTI**	**FTSE100**	**WTI**	**TOPIX1000**	**WTI**
β_0	**0.0004**	-0.0024	**-0.0005**	-0.0176	**-7.39E-05**	-0.002	**-0.0009**	-0.0026	**-0.0001**	-0.0026
	(0.7128)	(0.0142)	**(0.6832)**	(0.0000)	**(0.8862)**	(0.0195)	**(0.0383)**	(0.0042)	**(0.7356)**	(0.0080)
β_1	**0.1325**	0.0587	**-0.8173**	-0.167	**0.0663**	0.0108	**0.2691**	0.0247	**0.7259**	0.1836
	(0.6656)	(0.2775)	**(0.0000)**	(0.3376)	**(0.8522)**	(0.8760)	**(0.8022)**	(0.6575)	**(0.0021)**	(0.3643)
β_2	**-0.071**	-0.1458	**0.8458**	0.1501	**-0.1113**	-0.0403	**-0.2708**	-0.0774	**-0.7176**	-0.2238
	(0.8156)	(0.0089)	**(0.0000)**	(0.3954)	**(0.7528)**	(0.5656)	**(0.8014)**	(0.1751)	**(0.0029)**	(0.2632)
β_3	**0.0073**	0.1368	**0.0448**	0.9899	**0.1153**	0.1178	**0.1514**	0.1404	**0.0281**	0.1223
	(0.9164)	(0.0155)	**(0.6165)**	(0.0000)	**(0.0825)**	(0.0253)	**(0.1601)**	(0.0098)	**(0.4433)**	(0.0177)
β_4	-	0.0063	-	0.0015	-	0.0048	-	0.0055	-	0.0014
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_0	**5.68E-06**	4.92E-06	**2.53E-06**	9.41E-05	**5.44E-06**	2.12E-06	**3.59E-06**	1.85E-06	**5.50E-06**	7.53E-06
	(0.0000)	(0.0010)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0904)	**(0.0000)**	(0.2485)	**(0.0000)**	(0.0000)
γ_1	**0.0772**	0.0178	**0.0452**	0.1229	**0.1434**	0.0224	**0.1366**	0.0246	**0.1242**	0.0208
	(0.0000)	(0.0046)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0034)	**(0.0000)**	(0.0002)	**(0.0000)**	(0.0026)
γ_2	**0.9052**	0.9036	**0.9448**	0.6331	**0.8179**	0.8978	**0.8278**	0.904	**0.8412**	0.9038
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	0.0947	-	0.0911	-	0.1117	-	0.0932	-	0.1118
	-	(0.0000)	-	(0.0001)	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_4	-	5.79E-06	-	-1.04E-05	-	7.57E-06	-	7.23E-06	-	4.28E-07
	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.0000)	-	(0.7529)
γ_5	-	-7.61E-05	-	4.19E-05	-	-4.13E-05	-	-6.83E-05	-	-2.16E-05
	-	(0.0000)	-	(0.0190)	-	(0.0003)	-	(0.0000)	-	(0.0282)
γ_6	-	9.87E-05	-	2.14E-06	-	3.82E-05	-	6.67E-05	-	3.93E-05
	-	(0.0000)	-	(0.0015)	-	(0.0003)	-	(0.0000)	-	(0.0004)

Where RTSI = Russia security market, SZSE = China stock market, NASDAQ100 = US Equity market, FTSE100 = UK Equity market, TOPIX1000 = Japan stock exchange, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, β_3 denotes the parameter of GJR-GARCH, γ_4 denotes the parameter of volatility spillover, γ_5 denotes the parameter of COVID intercept with volatility and γ_6 denotes the parameter of COVID slope with volatility spillover

oil market except from Japan equity market to WTI which shows no volatility spillover. It implies that volatility in equity markets of Russia, US and UK transmit to WTI except for Japan equity market which shows no volatility transmission to the oil market volatility. If volatility of these markets is increases, the oil market volatility also responds accordingly. Only if the volatility in the China equity market increases, the oil market volatility will be decreases because the sign is negative. By looking at the spillover from equity market to the oil market, the results of COVID intercept γ_5 is negative and significant for all, which implies that the COVID period volatility of the oil market is different from the volatility of normal period. The negative sign implies that volatility of the COVID period is low from all equity markets to the oil market except China equity market because the positive sign indicates that the COVID period volatility is high from China equity market to the volatility of WTI.

Finally the parameter of γ_6 is significant and positive from all the equity markets to oil market (WTI) which confirms that there is an impact of the COVID-19 pandemic on the volatility transmission from the equity markets to the oil market. It proves that volatility spillover is different from China to WTI, Russia to WTI, US to WTI and UK to WTI in the event of the COVID-19 pandemic. Although in case of Japan there is no spillover from the equity market to oil market but due to the COVID-19 pandemic, volatility spillover exists from Japan equity market to the oil market. In normal period the volatility of Japan equity market did not transmit to the volatility of the oil market but the COVID pandemic has made the volatility transmission possible in between Japan equity market and WTI. Moreover positive sign is the indication that volatility spillover is high in the COVID period as compared to normal period.

So the conclusion is that the COVID-19 pandemic has a significantly high impact on the volatility spillover. Shocks produced by the COVID-19 pandemic has caused higher volatility in the above mentioned equity markets which are transmitted highly to the oil market volatility suggesting that the COVID-19 pandemic has a great impact on the equity market and the oil market link. US, UK, Russia, Japan and China have recorded the most number of cases due to which the investor

TABLE 4.15: Volatility Spillover from Equity Markets to the Oil market during the COVID-19 crisis - ARMA-GJR-GARCH-M Model

	DAX	**WTI**	**ITALY50**	**WTI**	**CAC**	**WTI**
β_0	**-0.0005**	-0.0016	**-0.0011**	-0.0021	**-0.0003**	-0.0009
	(0.4297)	(0.1014)	**(0.1645)**	(0.0217)	**(0.7046)**	(0.3008)
β_1	**0.1335**	0.046	**0.2376**	-0.0129	**0.1058**	0.0434
	(0.6626)	(0.5126)	**(0.5188)**	(0.8504)	**(0.9047)**	(0.4965)
β_2	**-0.1283**	-0.087	**-0.2783**	-0.0264	**-0.0897**	-0.092
	(0.6765)	(0.2225)	**(0.4453)**	(0.7068)	**(0.9194)**	(0.1556)
β_3	**0.1068**	0.1174	**0.1047**	0.1181	**0.0951**	0.0645
	(0.1017)	(0.0430)	**(0.1046)**	(0.0359)	**(0.1354)**	(0.2232)
β_4	-	0.0045	-	0.0043	-	0.0047
	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_0	**3.01E-06**	3.09E-07	**5.02E-06**	4.90E-06	**3.20E-06**	2.01E-06
	(0.0000)	(0.8272)	**(0.0000)**	(0.0035)	**(0.0000)**	(0.2117)
γ_1	**0.089**	0.0833	**0.0961**	0.0227	**0.1346**	0.0265
	(0.0000)	(0.0000)	**(0.0000)**	(0.0013)	**(0.0000)**	(0.0003)
γ_2	**0.8921**	0.8986	**0.8854**	0.9037	**0.8463**	0.9005
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
γ_3	-	-	-	0.0996	-	0.1018
	-	-	-	(0.0000)	-	(0.0000)
γ_4	-	8.25E-06	-	3.94E-06	-	6.75E-06
	-	(0.0000)	-	(0.0013)	-	(0.0000)
γ_5	-	-5.06E-05	-	-5.45E-05	-	-5.66E-05
	-	(0.0000)	-	(0.0000)	-	(0.0000)
γ_6	-	6.26E-05	-	7.26E-05	-	6.18E-05
	-	(0.0000)	-	(0.0000)	-	(0.0000)

Where DAX = German Equity market, CAC = France stock market, values in the parenthesis denotes the P-value. β_4 denotes the parameter of mean spillover, γ_4 denotes the parameter of volatility spillover, γ_5 denotes the parameter of COVID intercept with volatility and γ_6 denotes the parameter of COVID slope with volatility spillover

sentiment is affected and that has produced the shocks in their financial markets due to which those shocks are transmitted to the oil market as well and so the demand for the oil is decreases and oil prices fluctuated to an abnormal level.

Table 4.15 investigates the parameters of volatility spillover from some of developed countries equity markets to WTI during the COVID period. Equity markets include Germany, Italy and France. ARMA (1, 1)-GJR-GARCH (1, 1)-M model is used to identify the COVID-19 impact on the volatility spillover from financial markets to the oil market. The coefficient of ARCH term, γ_1 has significant positive results for all the equity markets. It means that past price behavior influences the current volatility. We can forecast current volatility through past price movements in countries like Italy, Germany and France. The coefficient of GARCH term, γ_2 has also significant positive results which show that there is persistence of volatility in equity markets of France, Italy and Germany. The sum of coefficients of γ_1 and γ_2 is equal to 0.981 which is same for all the three equity markets. It concludes that persistence of volatility is long run in nature because the figure is closer to 1.

From Germany to WTI, Italy to WTI and France to WTI, the parameter of volatility spillover γ_4 is significant which means that volatility in Germany equity market, Italian stock market and French financial market transmit into the oil market. If volatility is high in these markets, the oil market volatility also be high because the sign is positive. Simply we can say that volatility in these markets affect the volatility of the oil market. By looking at the spillover from equity market to WTI, the results of COVID intercept γ_5 are negative and significant which implies that volatility during the COVID period is low in the oil market as compared to volatility in normal days. Due to the COVID-19 pandemic there is a change in the volatility of the oil market which confirms the impact of the COVID-19 pandemic on the oil market (WTI).

Similarly the results of γ_6 are also significant which means during the event of COVID-19, the volatility spillover is different in case of Germany to WTI, France to WTI and Italy to WTI. Moreover positive sign shows that spillover was high during the COVID period. So here the point to be noted is that the COVID-19

pandemic has greatly influenced the volatility of the Germany, France and Italy markets which is followed by high transmission of volatility to the oil market which confirm the fact that these European developed countries are the epic centers of the COVID-19 pandemic. These countries have confirmed the highest number of affected cases and have got high mortality rates due to which it affected the equity market and the oil market link and so the oil market prices have gone down to an abnormal level in the history. The conclusion to the above discussion is that the equity markets shocks are transmitted to the oil market due to which the demand for oil decreases in both emerging and developed countries.

From the above discussion the nexus between the oil market and equity market is very strong especially during the COVID-19 pandemic. The oil market variations are closely connected to the equity markets of developed markets and emerging markets. Similarly the developed countries and emerging countries have also a close connection to the oil market. The COVID-19 pandemic has caused some big variations in these markets and these variations are enough to decrease the demand of oil in international markets. So the COVID-19 pandemic has severely affected the oil market WTI along with both developed and emerging markets.

Chapter 5

Conclusion & Recommendations

5.1 Conclusion

The main purpose of this study is to find out the impact of COVID-19 pandemic on returns and volatility of the equity markets and the crude oil market. Especially in the context of COVID-19 emergency, this study has also focused on the spillover from equity market to the oil market and the spillover from oil market to equity markets. Western Texas Intermediate (WTI) represents the crude oil market in this study. This study includes six developed countries equity markets and six emerging countries equity markets i.e. NASDAQ100 from the United States, FTSE100 from the United Kingdom, TOPIX1000 from Japan, DAX from Germany, ITALY50 from Italy, CAC from France, KSE100 from Pakistan, BOVESPA from Brazil, RTSI from Russia, SA40 from South Africa, BSE500 from India and SZSE from China. These developed countries and emerging countries are selected on the basis of highest COVID-19 cases, higher volatile markets and their influence on the performance of the oil market.

This study employs the methodology of ARMA GARCH-M model to check the mean and volatility spillover between equity market and the oil market in both directions. GJR-GARCH model is used to explore the influence of good or bad news on the volatility of both stock market and oil market. A COVID dummy is used in the ARMA-GARCH-M model as an intercept and slope dummy to find

the impact of COVID-19 pandemic on oil-equity returns, volatility and its spillover from both directions. On the basis of COVID announcement date by WHO i.e. 30th January, 2020, the COVID dummy is constructed which take the value of 1 for observations during the period February 1, 2020 till October 9, 2020 and 0 for the rest of period. The time period of the study is taken from the period January 1, 2010 to October 9, 2020. The COVID dummy is used with both mean and volatility equation but independently.

There exists a bidirectional returns spillover between the WTI and equity markets of United States, U.K., Japan, Germany, France, Italy, Brazil, Russia, India, China and South Africa which means any fluctuation in the oil market will have consequences on these equity markets and vice versa. Only in case of Pakistan, this relationship is insignificant in both directions with WTI which means both market returns have no influence on each other. In case of volatility spillover there is unidirectional relationship from China to WTI and WTI to Japan.

The oil market volatility is influenced by the volatility of Shenzhen stock exchange and Tokyo stock exchange is influenced by the volatility in oil market but from WTI to China equity market, there is no volatility spillover. The Chinese financial market volatility is not influenced by the changing volatility of the oil market. On the other hand positive bidirectional volatility is found between WTI and U.S., U.K., Germany, Italy, Brazil, Russia, South Africa, Pakistan and France which indicates that these emerging and developed equity markets are highly connected with the oil market that higher volatility in oil market or these equity markets are followed by higher volatility in the respective market. There is significantly negative volatility spillover from India to WTI which means high volatility in Indian financial market will be negatively transmitted to the oil market.

The COVID dummy used as intercept in mean equation of GARCH model shows significantly positive results in case of returns of WTI, U.S., Germany, and France While the results of U.K. equity market is negatively significant. BRICS countries including Japan and Pakistan show insignificant results which shows no big difference between COVID period returns and normal period returns. The intercept dummy in the volatility equation show negatively significant results in

case of Germany, Italy equity market and WTI oil market which confirms that volatility in these markets were low during the COVID period. Other developed and emerging countries have insignificant results which mean that there is not much difference between COVID period volatility and normal period volatility.

The outcomes of COVID slope dummy used in the mean equation is positively significant in case of spillover from the equity markets of Pakistan, India, Brazil, South Africa, Germany, Italy and France to the oil market WTI which means that returns spillover was high during the COVID-19 pandemic while in case of spillover from Russia, China, U.S., U.K. and Japan to the oil market WTI, mean spillover is insignificant which shows that during COVID period there is no effect on spillover from equity market to oil market. Here the COVID-19 pandemic has shown its impact on the spillover from Pakistan to WTI because there was no returns spillover before the COVID period but the COVID hype has caused the returns spillover from Pakistan equity market to the oil market.

The mean spillover during COVID period from oil market to equity market is insignificant only in case of Brazil which shows returns spillover from Brazil equity market to WTI is same during non-COVID period and COVID period which confirms that COVID-19 pandemic has no relationship with the returns spillover from oil market to Brazil equity market. Further findings explore that due to COVID-19 high variations in the returns of WTI are followed by high variations in the equity markets of United States, United Kingdom, Japan, Germany, Italy, France, Russia, India, China, South Africa and Pakistan because the results are positively significant.

The outcome of COVID slope dummy in volatility equation shows that volatility spillover during the COVID-19 period is highly significant between WTI and equity markets except Japan equity market because the results show only a unidirectional spillover from Japan to WTI during COVID period. High volatility in the oil market by the COVID-19 has a result of higher volatility in equity market and vice versa because the sign is positive in all cases. Only Japan equity market shows no response to the high COVID volatility in the oil market. All other developed equity markets and emerging equity markets shows bidirectional relationship with

WTI in case of volatility spillover during the COVID-19 pandemic because the results of slope COVID dummy are all significant. An interesting point here that China stock market volatility is not influenced by the changing volatility of oil market but during the COVID-19 pandemic, the scenario has changed significantly and so the higher volatility due to COVID in the WTI is transmitted to the China equity market.

The GJR GARCH or TGARCH shows asymmetric behavior in case of WTI, Brazil, Russia, India, South Africa, Pakistan, U.S., Germany, Italy and France which means that bad news create more volatility in these markets. The London stock market, Japan equity market and Chinese financial market have the same response to both good news and bad news because the results are insignificant for these markets. The GARCH-M model reveals that the WTI oil market returns can be predicted by the forecasted volatility. Furthermore, South Africa, U.K., France and Italy returns can also be predicted by the forecasted volatility because their results are significant positively.

5.2 Recommendations

The impact of COVID announcement on the equity market and oil market is the prime objective of this study. The investor behavior is changed by the fluctuations in both these markets. During the uncertain situation of pandemic, it is very difficult for them to invest in the less risky stock markets. Connection of oil market with the equity market is of great importance in modern era. So fluctuation in oil market will have an impact on the equity market and vice versa. This study explores those emerging and developed markets which are the worst hit by the pandemic in connection with the crude oil market. Findings suggest that Japan equity market is very safe for the investment because the study reveals that there is no spillover in between WTI and Japan equity market during the COVID emergency. Similarly the Brazil market returns were not influenced by the oil market variations due to COVID which means it is another less risky option for international investor to invest in Brazil financial market. The study recognizes

those financial markets that are actually affected after the news of COVID-19. Most affected include China, Pakistan, U.S., U.K., Germany, Italy and France so the authorities can make policies on the basis of this study by employing unlimited quantitative easing and zero interest rate policy in order to help out in reviving these economies. The study contributes to economic policies of emerging and developed countries during post-COVID period. This study is also helpful in terms of investors perspective and the decision makers will be able to make the investment decisions in the pandemic situation. This study will also be helpful for the government to keep an eye on stressful situation. In a nutshell following points are concluded:

- Pandemic affects the returns oil market WTI, U.S., Germany, France and U.K. so the pandemic is priced by these markets.
- COVID-19 Pandemic affects the volatility of WTI, Germany and Italy so these are the markets with high risk so pandemic is priced by these markets.
- The COVID-19 pandemic affect the link between WTI and all equity markets except Brazil and in reverse it affect the link between equity markets of Pakistan, India, Brazil, South Africa, Germany, Italy, France and WTI. So there is a diversification opportunity for investors in all risky equity markets except Brazil equity market especially during the uncertainty of pandemic.
- The COVID-19 pandemic affects the volatility spillover link between WTI and all equity markets except Japan which mean high degree of risk is present in both oil and equity markets so these countries with high risk may focus on risk management by making best policy decisions. The Japan equity market is the best choice for investment during the pandemic.

5.3 Limitations and Future Directions

This study is limited to six emerging equity markets and six developed equity markets along with crude oil market WTI. The COVID-19 pandemic has spread to more than 220 countries across the globe so there is big gap to study the imp-

-act of COVID pandemic on the financial markets of all affected countries. The developed and emerging equity markets can also be explored with the Brent crude oil market. Moreover sectorial based analysis can also be explored from industry to industry. This study used the data till 9th October, 2020. Recently the world is experiencing a second more fatal wave of COVID-19 pandemic, so the study can be further explored with a more recent data set. Another big gap to be filled is the impact of vaccination in reviving the economies of world markets.

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Appendix A

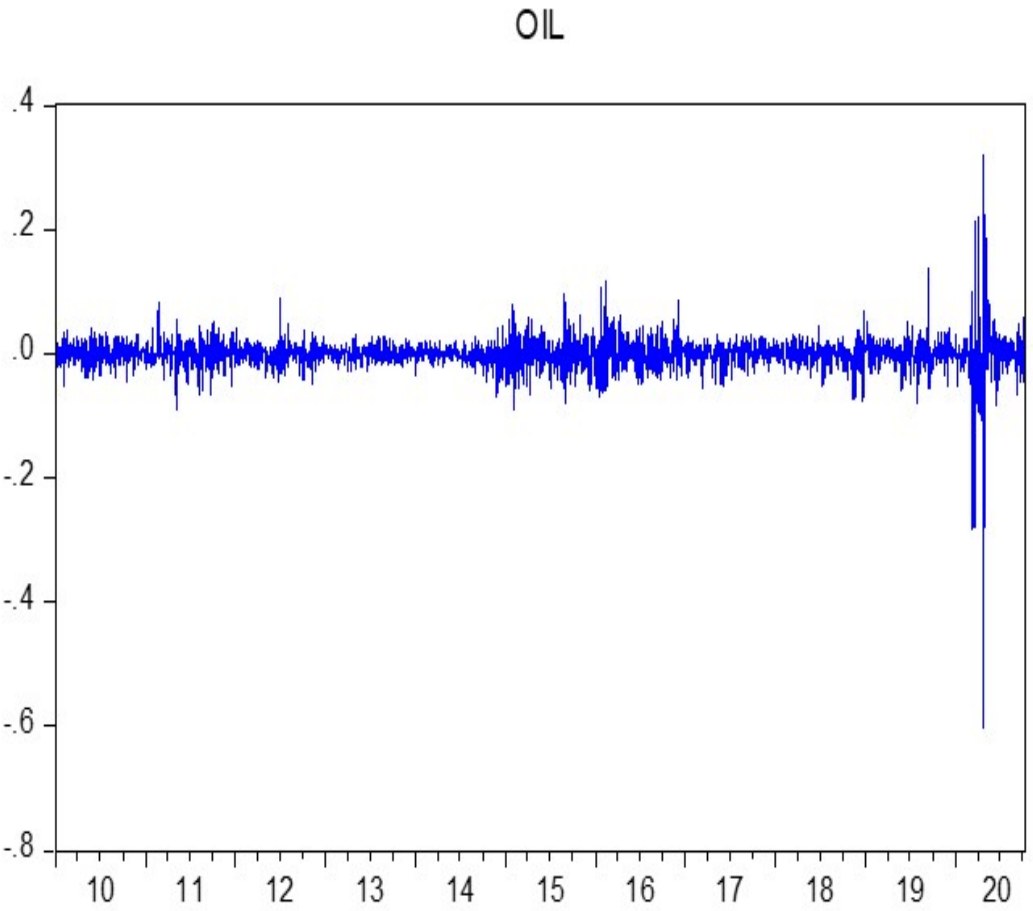

FIGURE 5.1: Returns of WTI Crude Oil Market

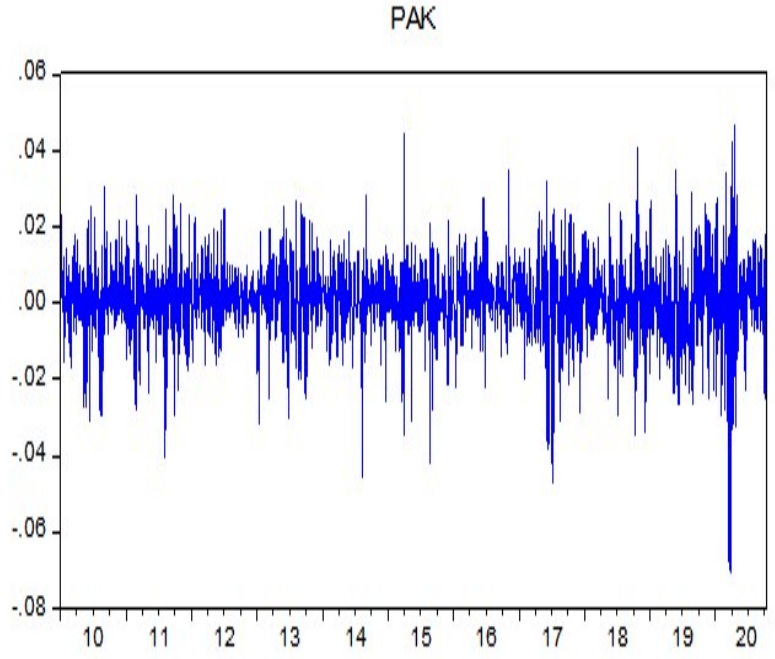

FIGURE 5.2: Returns of Pakistan Stock Exchange

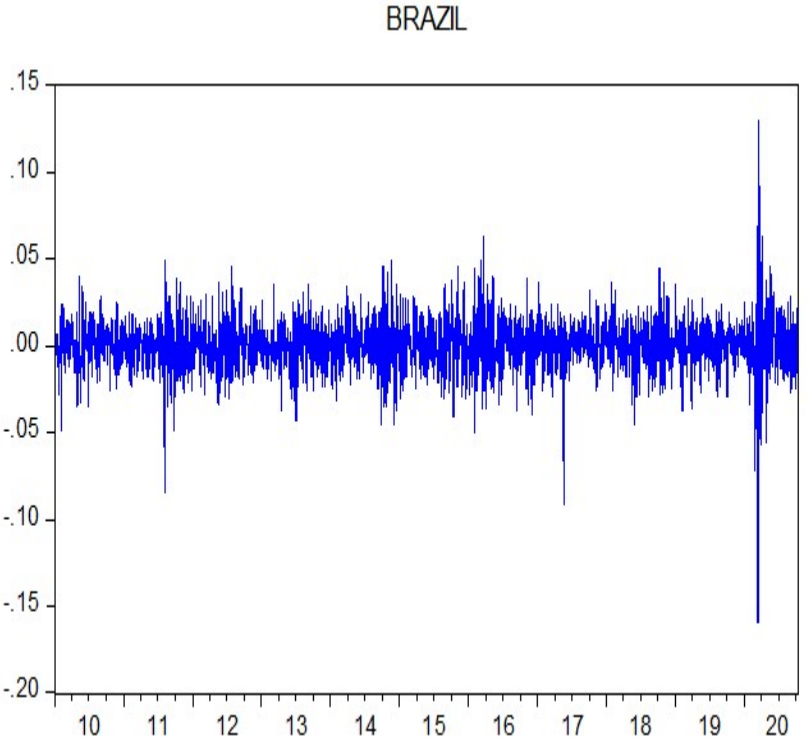

FIGURE 5.3: Returns of Brazil Equity Index (BOVESPA)

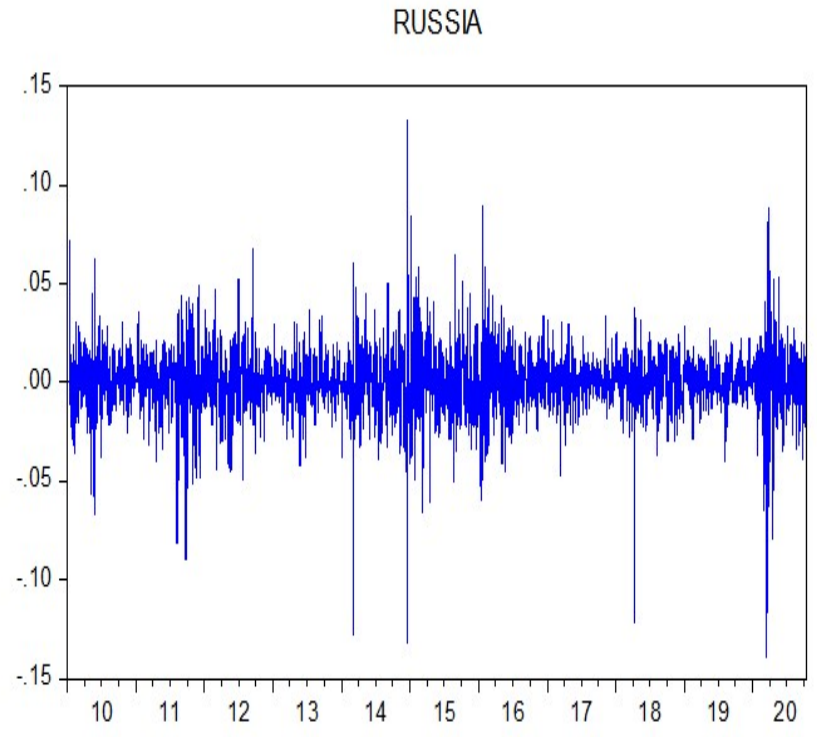

FIGURE 5.4: Returns of Russian Stock Market (RTSI)

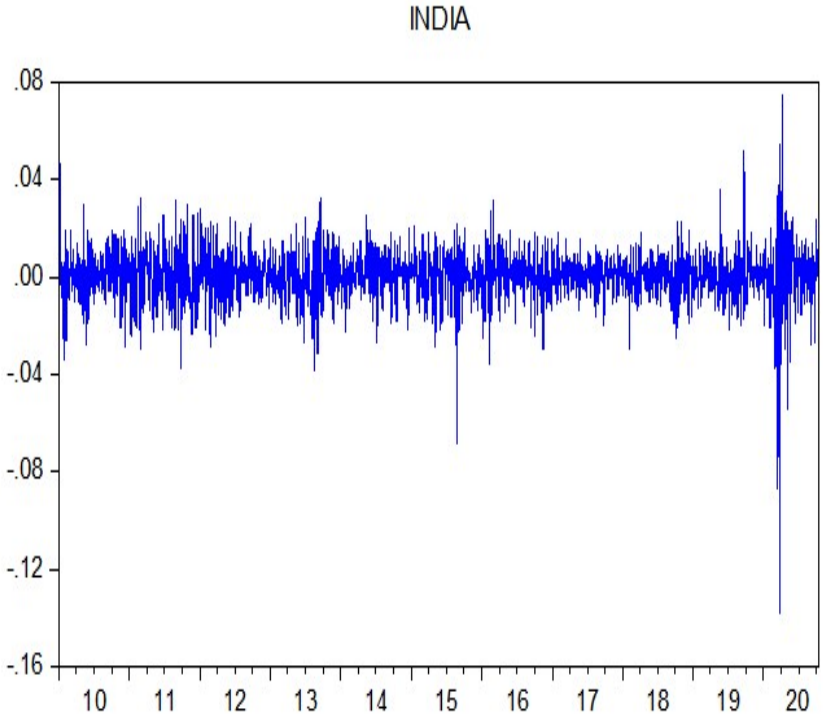

FIGURE 5.5: Returns of Indian Stock Exchange (BSE500)

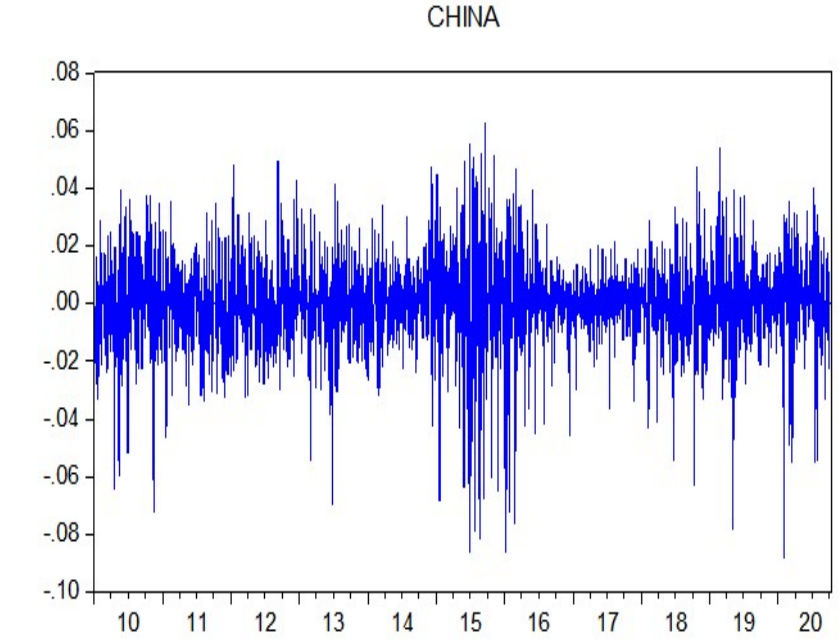

FIGURE 5.6: Returns of Chinese Equity Market (SZSE)

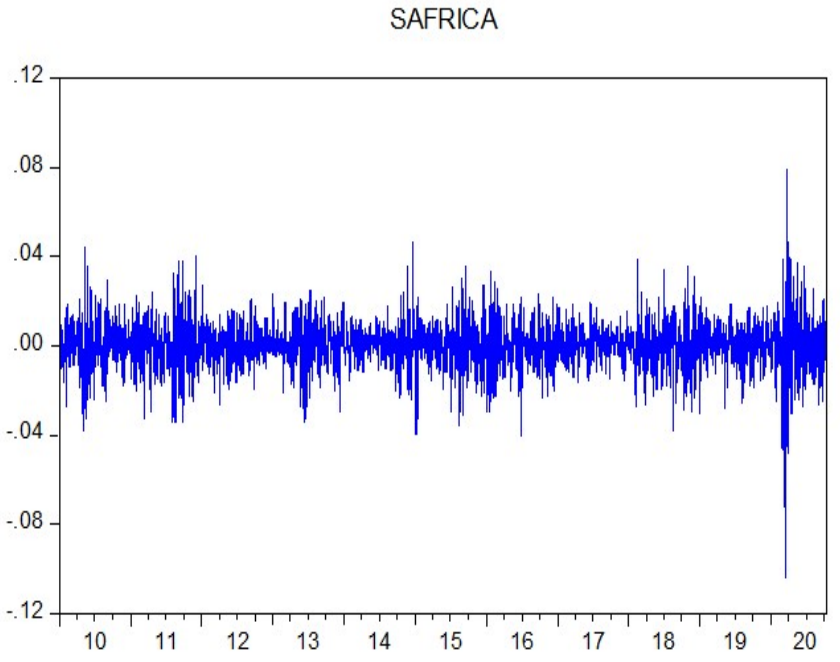

FIGURE 5.7: Returns of South African Stock Exchange (SA40)

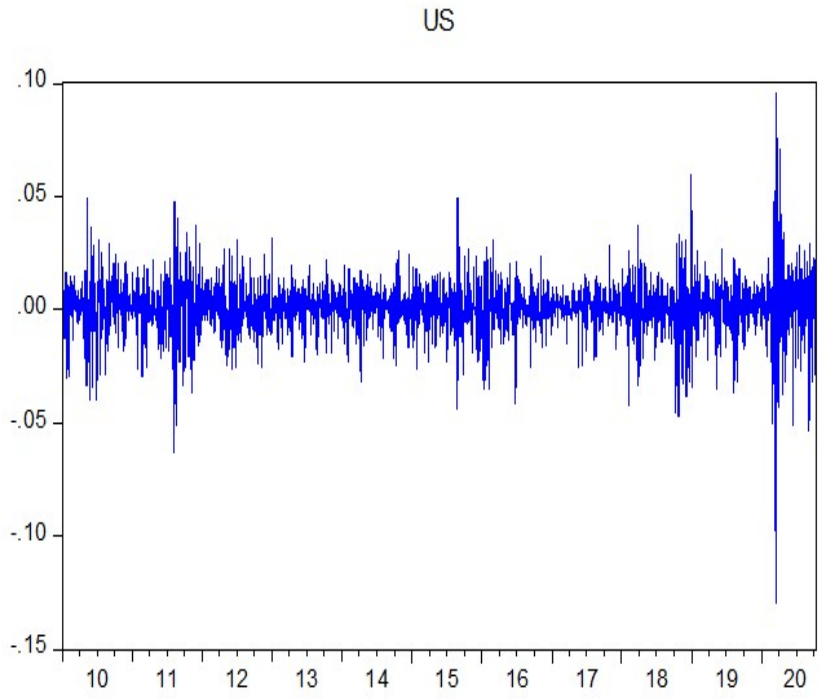

FIGURE 5.8: Returns of United States Stock Market (NASDAQ100)

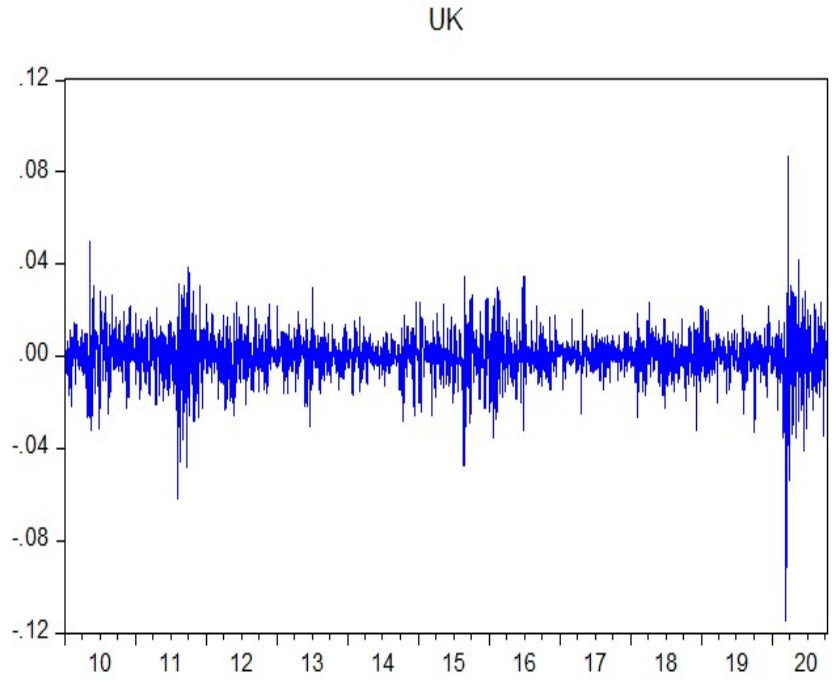

FIGURE 5.9: Returns of United Kingdom Equity Market (FTSE100)

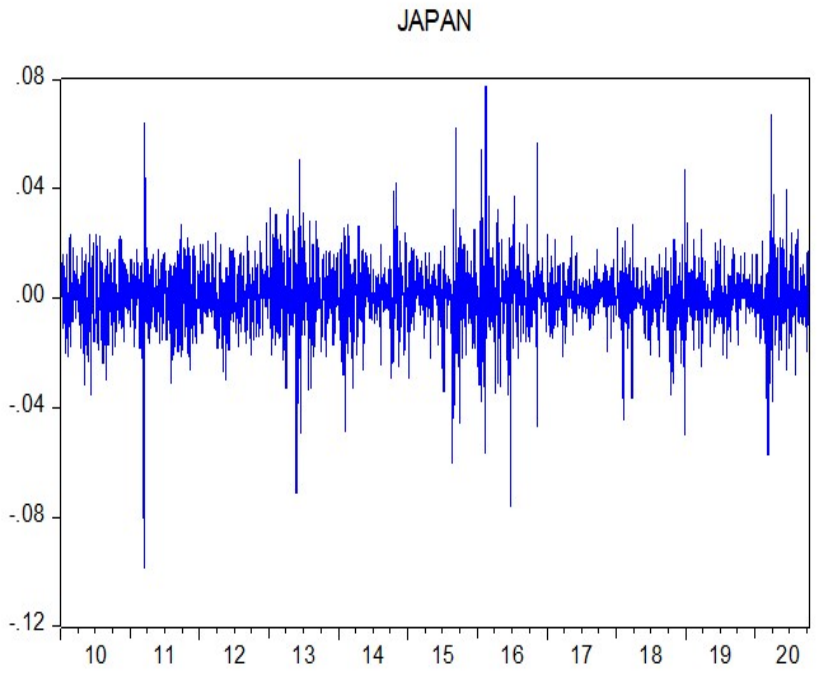

FIGURE 5.10: Returns of Japanese Stock Market (TOPIX1000)

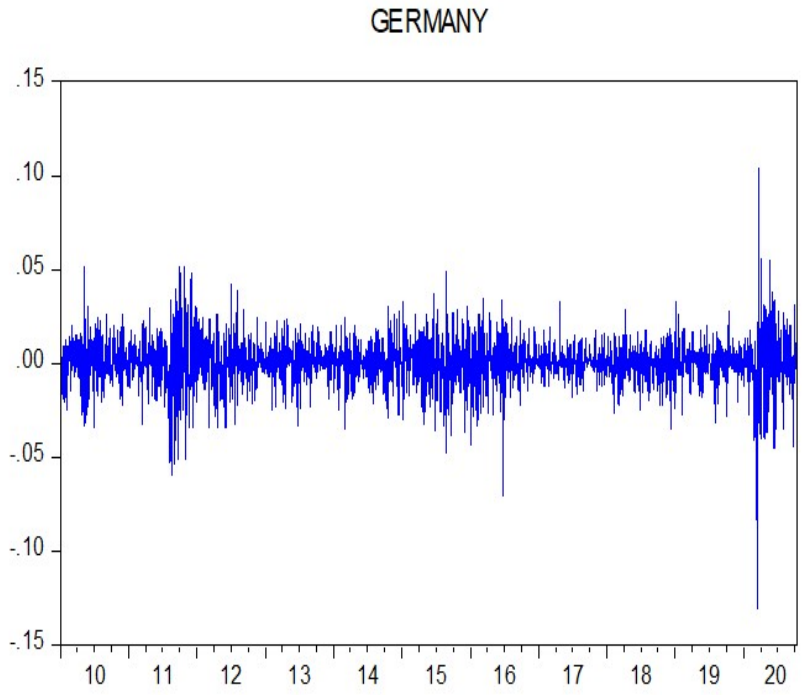

FIGURE 5.11: Returns of German Equity Index (DAX)

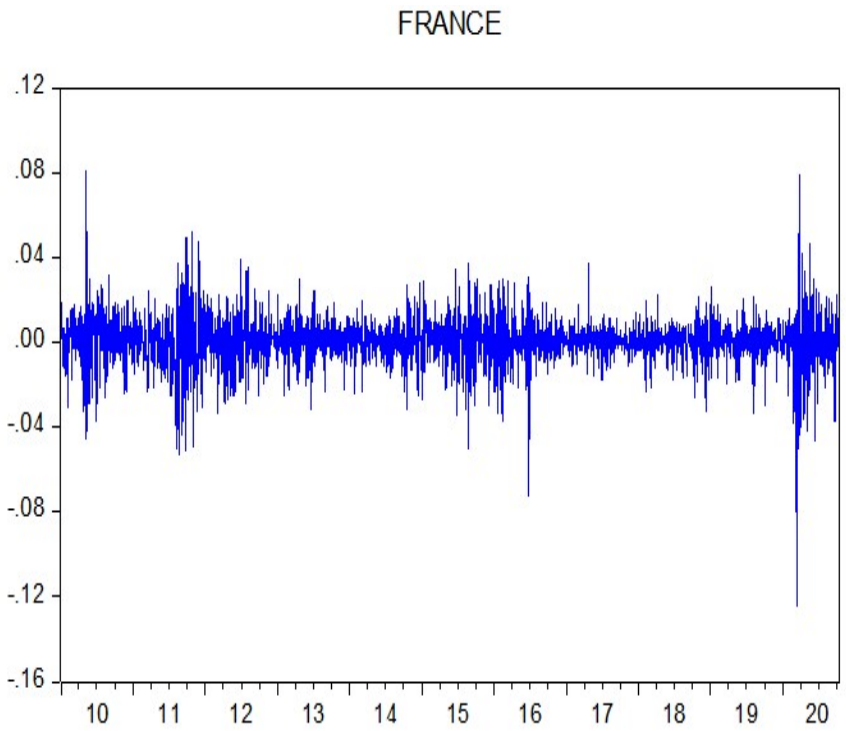

FIGURE 5.12: Returns of French Stock Index (CAC)

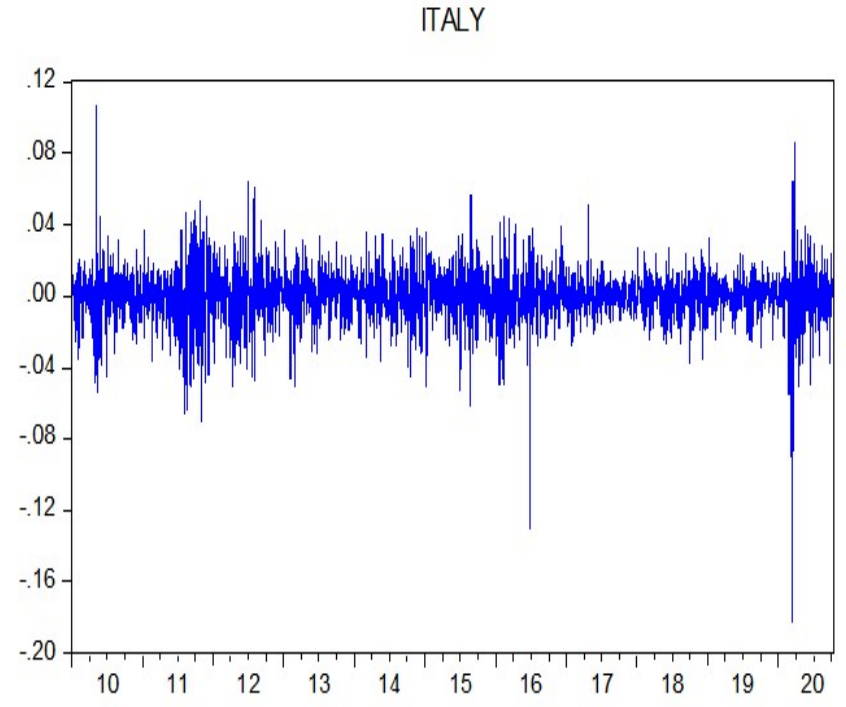

FIGURE 5.13: Returns of Italian Equity Market (ITALY50)