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Impact of Crude Oil Market on the South Asian Equity Markets: Copula Approach

by

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I want to dedicate my work to my parents

CERTIFICATE OF APPROVAL

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Abstract

The study aims to identify the long-term and short-term connection, time varying correlation, and dependence structure among Crude Oil Market and South Asian equity markets. The study uses the daily returns of crude oil and South Asian equity markets for the period of January 01, 2000, to June 2019. ARMA-GARCH (1,1) is utilized to examine the spillover effect of the Crude Oil Market to the South Asian equity market. The Vector Auto Regression (VAR) model is applied to test the short-term connection among the considered markets. Moreover, the dependence structure is measured by using the copula approach. The study finds the significant transmission of the volatility from the Crude Oil Market to South Asian equity markets.However, return spillover exists only in case of Bombay Stock Exchange. No evidences are found for the short-term relationship of the Crude Oil Market with South Asian equity markets. The results provide evidence of the presence of the time varying conditional correlation. The finding of the study also suggests the presence of some dependence between the crude oil and the South Asian equity markets. The nature of the dependence patterns of the Crude Oil Market, KSE-100, Dhaka Stock Exchange, and Colombo Stock Exchange is identical, and in the case of the Dhaka stock exchange, there is lower tail dependence. This study is useful for portfolio managers, risk managers, investors, and policymakers in portfolio structuring, diversification, and risk management.

Keywords: Spillover, Dependence, short-term relationship, Time-varying Correlation, ARMA-GARCH (1,1), VAR model, Copula, Crude Oil Market, South Asian Equity markets

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Abbreviations

ARMA-GARCH	Autoregressive Moving Averages GARCH
ADCC	Asymmetric Dynamic Conditional Correlations
BSX	Bombay Stock Exchange
CSX	Colombo Stock Exchange
C-EVT	Conditional Extremely Value Theory
DCC	Dynamic Conditional Correlations
DSX	Dhaka Stock Exchange
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GCC	Gulf Co-operation Council
KSE 100	Karachi Stock Exchange 100 index
VAR	Vector Autoregressive
WTI	West Texas Intermediate

Chapter 1

Introduction

Crude oil is an integral part of an economy and it is also considered as the driver of the economy. Firms are bound to use crude oil as input or output. Prices of this input or output units accelerate or deaccelerate the profit-generating capacity of the firms which specifies the direction of predicted future cash flows of the firms. Based on this expected future cash flows, the equity of the firm is priced by the market. If the expected future cash flows follow positive trends, the equity prices will follow the bullish trend and in contrast, if the cash flows of the firms follow a negative trend the equity price will face bearish trend in equity markets. So, the crude oil prices and Equity market indices are interlinked. This phenomenon cannot be studied on an individual basis. The nexus among crude oil and equity market prices is based on the economic theory and portfolio diversification theory.

1.1 Economic Theory and Crude Oil and Equity Market Linkage

Dependence structure among the crude oil market and equity markets prices can be elucidated by economic theory. According to economic theory, the price of an asset should be fixed by discounted future cash flows which are most closely relevant to it (Williams 1938; Fisher 1930). So that any factor which is associated with these cash flows changes the value of discounted cash flows and it also influences the prices of these assets. In the scenario of crude oil and equity market linkage, any increasing trend in the crude oil prices that will become the cause of the declining process in the equity market prices. Because this increment in the crude oil prices will increase direct and indirect costs like production cost or transportation cost, because of this increment the future cash flows will decrease and as a result, it would lead to a decrease in the firm's market capitalization. In this scenario, this incremental change in crude oil prices will decrease the prices of equity markets.

In second cases, if there is the decline in the crude oil prices will also reduce the costs associated with it like production or transportation cost which will lead to increase in business activities in an economy that will enhance the businesss cash flow which will increase the market capitalization of the firm, as a result, there will be increasing trend in equity prices. This positive or negative change in crude oil prices will create diversification opportunities for investors.

1.2 Portfolio Diversification Theory and Oil and Stock Market Linkage

Markowitz introduced the theory of portfolio diversification in (1952) which describes that investors are risk-averse. An investor always wants to make the portfolio of his investments instead of putting all the eggs in one basket. If two investments offer the same expected rate of return the investor will choose that investment with which low risk is associated. In the case of crude oil, crude oil prices are negatively interlinked with the equity market prices. The bearish and bullish trends are associated with it in different markets. As a result of these trends, the cash flows of the firms fluctuate across time. For minimization of the effect of these fluctuations, the investors diversify the portfolio to minimize its overall risk associated with these investments. If the country imports oil to meet the requirements of his economy then the high risk is associated with crude oil prices because oil is considered as the major source of fuel in the transportation sector, industrial sector, energy-producing sector, and in the household sector. If the price of crude increases it may directly affect the following sectors that lead to a change in equity prices of the different firms either negatively or positively. In previous literature Aloui, Nguyen, & Njeh (2012) it is discussed that the prices of crude oil are negatively correlated with stock market indices in the emerging economies. This argument is also supported by Asteriou & Bashmakova (2013) and finds that crude oil has a negative linkage with equity market prices of emerging economies.

1.3 Gap Analysis

Different studies have been carried out to check nexus among the crude oil prices and equity prices of the different emerging, and developed markets, and especially the markets of these countries, which are the main producers of crude oil but there is no consensus in the literature. Some authors discuss the significant linkage among the equity markets and crude oil and some authors reject these arguments, like, some (Wen, Bouri and cheng(2019) argue that there is a positive connection in the crude oil prices and stock market prices and contrast some studies Park and Ratti (2008) indicate no linkage in the prices of the crude oil and the equity market prices in several countries. These research studies are conducted in various markets of Africa, America, and Asia. In the South Asian countries context, few studies have been conducted by using the spillover and cointegration technique. The time-varying relationship among the South Asian stock markets has been studied by Sehgal, Pandey and Deisting(2018) by using cointegration analysis. But the dependence among the crude oil market returns and equity market returns of the South Asian countries has yet not been addressed by researchers so this domain requires investigation by using a copula approach. Some studies German and Kharoubi(2008), Zohrabyan (2008), Nguyen and Bhatti(2012), Wen et al. (2012) utilized the copula function to explore the dependence structure among different markets and conclude that copula approach is the best measure to capture the dependence structure among the financial markets. A copula function is the multivariate aggregate distribution for which the marginal probability distribution of every variable is symmetrical. The Copulas are mostly employed to study the dependency patterns of the different variables. Five copula functions like the Gaussian copula, the student T copula, Normal copula, Gumbel copula, and Clayton copula are normally used to study the dependence structure between variables. Gaussian copula uses normal distribution function, while student T copula talks about linear correlation coefficient and degree of freedom less than 30, Gumbel copula displays the greater dependence in the positive tail in contrast to Gumbel copula, Clayton copula shows the higher dependence in the negative tail.

1.4 Problem Statement

It has been observed that South Asian economies are fast-growing economies but all countries import a huge quantity of oil to meet the daily requirements of different sectors of economies. Due to this high dependence on crude oil, oil price fluctuation over the time. So, risk factor is associated with the equity markets of South Asian Countries. Impact of crude oil prices on the South Asian equity markets has not been studied collectively and the dependence structure among crude oil prices and equity market prices yet not explored. According to the portfolio diversification theory, usually investors do not want to take risks. Investors hesitate to invest in risky markets. Lack of the knowledge about the influences of the crude oil price on south Asian stock markets may lead to a decline in investor confidence. So, there is a need to conduct the study which explores the nexus of oil and equity markets with a focus on dependence structure among crude oil market and South Asian equity markets. This study provides in-depth knowledge about crude oil and South Asian Equity market dependence.

1.5 Research Questions

These questions are answered in this research study:

- Do crude oil prices significantly influence the stock market indices of South Asian countries in the short and long-run?
- Do crude oil prices have time-varying linkage with South Asian Equity markets?
- Is there exists any dependence structure among the returns of the crude oil and the South Asian Equity markets?
- Does the dependence structure on the left tail and the right tail differ?

1.6 Objective of the Study

The objectives of the study are as follow:

- To check the impact of crude oil prices on the market of South Asian countries.
- To examine the time-varying relationship among crude oil market and South Asian Equity markets.
- To provide insight into the dependence patterns among crude oil and stock market indices in South Asian countries.
- To explore the difference in the dependence structure on the left tail and on the right tail.

1.7 Significance of the Study

As we know that South Asian countries are emerging economies that have lots of opportunities for investment. Foreign investors show their interest in investing in these countries. Investors want to know the trends in stock market indices which is mostly affected by oil prices and the shift in the exchange rate. This study could be helpful for the development of effective strategies against oil price movement and helpful for the risk managers of the firms who want to minimize their risk and portfolio managers can also use this study for diversification purposes.

1.8 Plan of the Study

Chapter 1 discusses the introductory part of the study which contains the theoretical background, gap analysis, problem statement, research questions, research objectives, and significance of the study. Chapter 2 talks about the literature review of the past studies and contains the hypothesis which are developed from the literature. Chapter 3 includes the methodological section which is followed by this study, econometric model, data description. Chapter 4 discusses the data analysis and result which is obtained by using different statistical techniques. Finally, chapter 5 covers the conclusions, recommendations, and limitations of the study and the limitations of this research study provides the gap for the future research studies.

Chapter 2

Literature Review

During the past few decades because of the increasing demand for crude oil and high-fluctuation of its prices, the researchers have paid much attention to this area. Different researchers have scrutinized the long-term relationship, short-term nexus, and the time-varying association between the crude oil and equity markets of various countries. Subsequently, some empirical studies have been conducted to check the equity market dependency on crude oil during different periods. The literature review for this study is categorized into three sections. In the first part, long term and short-term relationships are discussed, the second part discusses time-varying correlation among crude oil returns and different equity markets and in the last section, literature related to dependence structure has been reviewed.

2.1 Long and Short-term and Spillover Analysis between the Oil Market and Equity Markets

Many studies have applied different statistical techniques to test the long term and short-term relationship between financial assets. This study is concerned with checking the spillover by using ARMA GARCH (1,1) and short and long-term linkage among crude oil market and equity markets linkage is observed by applying Vector Auto-Regressive model. So, in this context, different researchers like Mohammadi and Su(2010), Phan, Sharma, and Narayan (2014) and Wang and Liu(2015), uses ARMA-GARCH family and similarly, Cong, Wei, Iao and Fan (2008), Fayyad and Daly (2010) and Hatemi-J, Shayeb and Roca (2016) employ the Vector Auto Regressive model to forecast the short term and long term nexus and risk and returns spillover in crude oil market and equity market of different countries. These authors suggest that both techniques are valid and show consistent results in this regard.

Malik and Hammoudeh (2007) by using the GARCH model explore the risk and returns transmittal mechanism between the US equity market, global oil market, and equity markets of Saudi Arabia, Kuwait, and Bahrain. The findings of the study disclose the volatility transmission from the oil market to equity markets of Gulf countries. Beside these findings study also conclude that the effect of spillover among the considered markets moves in both directions from the crude oil market to these equity market and vice versa. Another study by Bhar and Nikolova(2009) explore the relationship in oil and equity markets by utilizing GARCH models and states that despite global economic crises oil prices do not significantly influences the BRIC,s equity market but in case of Russia which is net oil exporters surprisingly shows the significant relationship which means that prices of Russian equity markets are forecasted by crude oil prices.

Mohammadi and Su (2010) have studied different prospects of the oil market by using ARMA-GARCH models. The study is conducted to check the linkage in the crude oil market and eleven global equity markets of oil-importing and exporting countries for the period 1997 to 2009 using weekly spot returns of crude oil and weekly equity market returns of the concerned equity markets. The study concludes that the conditional variance of oil returns shows the time-varying volatility. However, the response for asymmetric behavior in conditional variance is mixed. Besides this phenomenon, no evidence is found of return and volatility spillover in the given time frame.

Arouri, Jouini, and Nguyen (2013) by deploying the VAR GARCH model in different European and US equity markets find the interactive transferal process of risk from the oil market to the equity market and finds bilateral volatility transmittal process in the case of US stock markets. Phan, Sharma, and Narayan (2014) have conducted a study by using ARMA GARCH model in oil-producing and consuming countries to forecast the nexus among the prices of the crude oil market and equity market prices and find that in case of oil-producing countries return of equity markets have positive linkage with crude oil prices regardless of whether the prices increases or decreases while in case of oil-consuming countries statistical outcomes report that the oil returns do not have a statistically significant impact on all sectors of the particular economy. Kang, Ratti, and Yoon (2014) examine the linkage of fundamental shocks in the oil prices with US equity markets by using ARMA GARCH (1,1) to disclose that positive shifts in the oil market significantly negatively influences the return and volatility of equity markets.

Mokengoy (2015) applies multivariate GARCH BEKK model to investigate the transmission process of the volatility among oil prices, exchange rate, and returns of equity market of Canada and the USA for the period of Jan04,1999 March 21, 2014. In the study, it is concluded that there is a significant bilateral volatility transferal process in the crude oil market and equity markets of Canada and the USA. It is also highlighted in the study that this volatility transmission is not stable over the period. Wang and Liu (2015) have conducted a study by using ARMA GARCH models on seven those countries which imports the huge amount of oil and nine developed major exporting economies and in the findings of the study it is mentioned that there is a unilateral transmission of risk from the crude oil market to oil-importing and exporting countries. This study also confirms that the correlation among the oil market returns and equity returns in oil-exporting countries is stronger than the oil-importing countries.

Ewing and Malik (2016) test the volatility spillover by utilizing the univariate and bivariate GARCH models among the oil market and US equity markets by placing structural break in the data in which study have concluded that there is no evidence of the transmission of risk among the oil market and US equity market when the structural break is ignored in the variance. Anyhow, by placing structural breaks in the econometric model the study proposes the strong volatility transmission between the markets. Liu, An, Huang, and Wen (2016) by using the wavelet-based GARCHBEKK method examine the transmission features among the oil market and Russian and American equity markets by dividing sample period into three parts post crises, pre crises and during crises. Results indicate that transmission features among the US equity market and the oil market are for a shorter period and these transmission features for the Russian equity market and crude oil prices are changing across the time. Results also indicate that there is a weaker association among oil market returns and returns of the US stock market within the sample time frame. Liu, Ding, Li, Jiang, Wu and Lv (2017) have conducted a comparative study to foresee the transmittal process of risk among global crude oil prices and equity markets in China and America for the period of 2003 to 2016 by employing the VAR-GARCH econometric model which suggest a bilateral return link from crude oil market to US equity market and unilateral transmittal process of risk from crude oil market to US stock market. However, in the case of china unilateral returns contribution is made by the crude oil market into the Chinese market and no evidence of risk spillover from the crude oil market to the Chinese stock market. According to this study, the nexus among the crude oil market to the Chinese stock market is following the increasing trend over the period so it should not be ignored.

Cheikh, Naceur, Kanaan, and Rault (2019) have studied linkage among crude oil market and GCC equity markets of using nonlinear smooth transition regression in which findings of the study disclose the negative shifts in the crude oil prices make the significant influence in the GCC stock market returns as compare to positive shifts in oil prices. The findings also reveal that returns of the equity market are sensitive to higher price shifts rather than small shifts in the crude oil prices and asymmetric patterns are observed in the considered markets. Another work done by Malik and Rashid (2019) which explains the linkage of the Brent oil market with different sectors of Pakistani stock exchange by applying Bivariate VAR (1)-AGARCH (1,1) model. The study reveal that the volatility associated with the Brent oil market hasnt made any significant contribution to sectors of Pakistan stock exchange not in short or in the long run in the examined sample period. But the mean spillover exists from the Brent oil market to different sectors of Pakistan stock exchange.

Another contribution made by Hammoudeh and Li (2004) which proposes a study by employing cointegration analysis to check oil price volatility and systematic risk in the riskiest equity indices of Mexico and Norway in which it has been concluded that any upward shift in the oil prices it will increase the stock prices of both countries. This study also suggests that the stock market of Mexico and Norway is much sensitive and systematic risk is also high in these markets. Investors while investing in these markets should consider the systematic risk more as compare to other factors.

Cong, Wei, Iao, and Fan (2008) conduct a study to check the linkage in the crude oil market returns and returns of the Chinese equity market by deploying the vector autoregressive model. It is indicated in the findings of the study that oil prices have not made any reasonable contribution to the Chinese real equity market indices expect the manufacturing companies and some petroleum companies. It is also discussed that oil prices minimize the returns of some oil companies. Park and Ratti (2008) have studied the association among the crude oil and the equity market by utilizing the Vector Autoregressive model in the USA and on 13 other European countries which conclude that oil prices significantly affect the real stock returns within the month.

Another study conducted by Kilian and Park (2009) confirms the results of the previously mentioned study which is conducted to see the association among the crude oil market and returns of USA equity markets by deploying the structural VAR model. which mentioned the significant mechanism of transmission of volatility from the crude oil market to US equity market returns. Both demand and supply related shock contributed to this volatility transmission process.

Apergis and Miller (2009) have checked the influence of prices shock on equity prices of Canada, Australia, France, Japan, USA, UK, Italy and Germany in which it has been discussed that global stock prices do not reciprocate in a large way to the movements in the oil prices. If a change in crude oil returns affects the global equity market prices, the magnitude of this effect will be very weak. Chen(2009) have investigated, do oil prices drive the equity prices towards the bear territory by applying Markov-switching Autoregressive (TVTP-MS-AR(q)) model in which the empirical results report that if the prices are shifting upward there are huge chances of shifting from a bull market to bear market. In this study, it also has been observed that higher prices keep the stock market in bear trend for a longer period. Another contribution made by Puah, Hong, Tan, Phin, Isa, and Hassan (2009) to assess the nexus of oil prices and returns of power generating industries in Malaysia by utilizing the Vector Auto Regression (VAR) model. The statistical results of the study are reported that world crude oil prices have a reasonable positive long-term relationship with Power generating industries registered in the Malaysian equity market. Scholtens and Yurtsever (2010) have conducted the study by using VAR and regression models to check the association of crude oil price shock with European countries' equity markets in which the finding of this study reveals that oil price shock negatively affects the returns of European industries. In this study, it is also mentioned that many industries take advantage of this negative linkage (i.e. decrease in oil prices) whereas these industries are not affected by the increase in oil prices. However, few industries related to gas, oil, and mining react in different manners. These industries get benefit from the upward movements in the oil prices but get affected badly by a decrease in prices of crude oil.

Fayyad and Daly (2010) have conducted a comparative study between the oil prices, GCC countries, the US, and UK equity markets by deploying the Vector Auto-Regressive (VAR) model. Statistical results reported in the findings of the study indicate the significant association between GCC countries. More ever, oil prices have a significant effect on returns of the equity market of GCC countries and as well as UK and US equity market returns but to varying degrees. Lin, Fang and Cheng (2011) have studied the association among the crude oil market return and Chinese equity market returns and returns of the Hong Kong equity market by deploying the SVAR model which describes that in the case of the Hong Kong equity market is significant but in a positive way linked with the crude oil market. It may be because the economy of Hong Kong is very closely affiliated with the global economy. However, in the case of the Chinese equity market, there is a mixed response. Firstly, the Taiwan equity market responds similarly to the US equity market response. Secondly, only supply-driven shocks significantly influence the Chinese equity market and no demand-driven shocks have a significant impact on Chinese equity market returns.

Arouri, Lahiani, and Nguyen (2011) study the return and risk linkage among international oil prices and GCC stock market returns by adopting a generalized VAR-GARCH approach on returns over the period 2005 to 2010. The result of the study reveals the presence of return and transmission of the risk among the crude oil market and stock market returns of GCC countries. Berk and Aydogan (2012) have assessed the linkage among the crude oil market and the equity market of Turkey under global liquidity conditions by deploying a vector autoregression (VAR) model. Statistical results reveal that there is a presence of an oil shock effect in Istanbul equity markets during different time regimes. Li, Zhu, and Yu (2012) investigate the linkage among oil returns and the equity market of china by using the estimates of panel cointegration. The findings of the study suggest that the real oil prices have a positive contribution to the sectoral stock returns in long runs.

Fayyad (2013) by using the (BEKK) and Vector Auto-regression (VAR) models concludes in his study that Gulf Co-operation Council (GCC) countries are significantly influenced due to shocks in oil prices and Saudi equity market returns can also be predicted by oil price returns. Indian scholars Cunado and Gracia (2013) have studied the association of the crude oil market and European equity markets by utilizing the vector autoregressive model and vector auto-correction model in which it has been concluded that negative shift in oil prices can change the dilemma of European equity market returns in a significant way. It is also discussed that most of the equity prices are determined by oil price shocks.

Babatunde and Adenikinju (2010) have checked the nexus of oil price shocks with Nigerian equity market returns by utilizing the vector auto-regressive methodology, which has concluded that there is no positive association among the crude oil market and equity market return of Nigeria, however, Nature of this response can be reverted depending upon the nature of shocks. The study has also discussed that there are no asymmetric patterns among the crude oil market and Nigerian stock market returns as it is indicated by statistical results. Degiannakis, Angelidis, and Filis (2013) have conducted the research study by deploying the VAR model and variance decomposition technique to check the transmittal process from the crude oil market to US equity market provides the predictive power to the US equity market. The study provides evidence of justifiable spillover of the risk from the crude oil market to Us stock market which means that this spillover can be utilized to forecast the returns of US stock markets.

Alikhanov (2013) has conducted a study by deploying the GJR-GARCH model to check to what extent the crude oil market, US stock markets, and eight different European stock markets have the mechanism of return and volatility transmission. By using statistical techniques, the study reveals the significant risk and returns transmission from the crude oil market and the US equity market to eight European equity markets. This effect moves in both directions either positive and negative side depends on the factors that affect this relationship. Ghosh and Kanjilal (2013) by employing nonlinear cointegration methodology have conducted a study to assess the nexus of crude oil market returns with Indian stock market returns in which the study concludes that change in global crude oil returns negatively influences the Indian stock exchange in different phases. The historical data in this study is segmented into different phases. But the prices of crude oil do not receive any effect in feedback form from the Indian equity market. The study also revealed that international crude oil prices are exogenously determined of return and volatility.

Marques and Lopes (2014) have checked the linkage returns of Portuguese equity market and oil price variations by developing the estimate by using vector autoregressive model in which it has been observed that none of the shocks in the oil prices, global supply driven shocks, global demand driven shocks, and precautionary demand shocks affect Portuguese stock market return. It means that PSI is mainly affected by its own dynamics. Gomes and Chaibi (2014) have also studied the oil prices nexus with equity prices of the MSCI Frontier Markets and the MSCI World by applying bivariate BEKK-GARCH (1,1) model. Significant transmission effect of crude oil into considered equity market returns have been found. Sometimes this spillover has a bidirectional effect between the considered markets. Aye (2015) has established the study to assess the effect of risk factors associated with crude oil on the South African equity market by deploying the bi-variate GARCH-in-mean vector autoregressive model. It has been concluded that the South African equity market returns are significantly negatively influenced by crude oil returns. The study, further discloses that this response is asymmetric and for a longer period. Kang, Ratti, and Vespignani (2015) have applied a structural Vector autoregressive model to check the effect of the shocks created in the oil prices. The statistical results indicate that US equity market returns are significantly positively influenced by supply-side oil price shocks, however, results are different in case of non-supply shocks.

Diaz, Molero, and Gracia (2015) investigate the association of the crude oil market returns by employing the VAR vector autoregressive model with G7 economies in which empirical findings suggest that G7 economies responded negatively to the movements in oil price volatility. These findings also indicate that world oil prices have more impact on their national-level oil prices volatility in G7 economies. Dhaoui, Abderrazak, and Saidi (2015) have studied the crude oil relationship with OECD countries by applying the Vector Autoregressive model and find that equity prices of oil-importing OECD countries are negatively influenced by the crude oil prices while stock indices of net oil-exporting countries are positively influenced by the crude oil prices. Bouri (2015) has explored the risk and return linkage among oil prices and Lebanese equity market returns by using VAR-GARCH (Vector Autoregressive-Generalized Autoregressive Conditional Heteroskedasticity) model in which unidirectional alliance among crude oil and returns of the Lebanese equity market has been reported. It is also concluded that this alliance among oil prices and Lebanese equity markets becomes stronger during the crisis.

Wadhwa and Khemka (2015) have conducted a study by granger causality test to forecast the returns and volatility influence of the Brent crude oil market on returns of the Indian equity market. The ganger causality test reveals the unidirectional influence of the crude oil market on returns of the Indian stock market. (Sahin,2015) have tested the relationship of crude oil and equity market returns of emerging markets (Turkish stock market) on daily data by applying cointegration analysis. It is documented that oil prices increase the forecasting ability in Turkish equity market returns which disclose the presence of an association among crude oil market and stock market return of Turkish stock exchange. Nazlioglu, Soytas, and Gupta (2015) have conducted a study on oil prices and financial stress and checked the transmittal mechanism of the risk from crude oil market to equity market returns by deploying VARMA-GARCH models between WTI index prices and Cleveland financial stress index. The sample period for this study is from 1991 to 2014. The purpose of conducting this study is to check the effect of oil prices in pre-crisis, in post-crisis, and in during crisis period. Statistical results report that there is strong evidence of the transmission of risk from the crude oil market to the Cleveland financial stress index and this effect is for a longer period. The volatility spillover causality test provides statistical proof for the transmittal process of the risk of the volatility from the crude oil market to the considered equity markets market in the post and pre-crisis periods. However, this effect touches the peak during the crisis period.

Hayky and Naim (2016) have checked the linkage of oil prices with Kuwait equity market returns by using the Markov switching model. The study finds that Kuwait's stock exchange is significantly affected by crude oil prices. During rapid uncertain shifts in oil prices, positive and significantly strong association has been found among the crude oil market and equity market return. However, when there are lesser fluctuations in the prices of crude oil then there no evidence of any kind of association among the oil market prices and equity market returns of Kuwait stock exchange. Hatemi-J, Shayeb, and Roca (2016) assess the impact of the crude oil prices on equity prices of major Global economies by using the VAR model and conclude that an upward shift in crude oil prices also increases the equity prices in the world, in the US and Japan while decreases the equity market returns of the German market. US and Japanese stock markets take the upward movement in oil prices as an indicator of good news while the German market considers it a sign of contraction in the equity market. Nusair (2016) applies ARDL methodology to check the influence of shocks related to oil returns on the equity returns of the

GCC countries in which asymmetric patterns have been found in all cases. The finding of the study suggests that a decrease in overall crude oil returns will reduce the equity prices of these economies. Raza, Shahzad, and Tiwari (2016) investigate the asymmetric linkage of oil prices, gold, and uncertainty associated with these on equity prices of emerging markets by employing nonlinear ARDL model. The findings of the study indicate that all considered emerging economies are negatively affected by crude oil prices. This study also indicates that equity markets of the emerging economies are much sensitive to bad news in uncertain economic conditions. Noor and Dutta (2017) by deploying the VAR-GARCH model have tested the nexus of the crude oil market with equity prices of south Asian countries and find that all equity markets receive risk effects form the oil market and none of the South Asian equity markets have affected the global oil prices.

Salisu and Isah (2017) revisit the crude oil price association with equity markets of oil exporting and importing countries by applying nonlinear panel ARDL model. Results indicate that returns of equity markets of both importers and exporters respond asymmetrically to changes in oil prices although the magnitude of every shock is stronger than the former. Wen, Wang, Ma, and Wang (2019) by using VAR for VaR analysis checked transmission of the risk from the oil market to equity markets. In this study, it is found that the stock markets of G7 countries receive the risk effect from the changes in oil prices. Bai and Koong (2017) have conducted a study by using structural VAR method to explore the nexus of the oil prices with the returns of the equity markets and exchange rate in US and China, finds that US equity market returns are significantly positively influenced by the crude oil prices, positive oil shock significant and negatively affects the returns of the Chinese equity market and Chinese equity market is more volatile and adjusts quickly to aggregate demand and supply shocks as compared to US stock markets.

Kisswani and Elian (2017) investigate the nexus of the oil prices with Kuwait equity markets returns by applying a nonlinear autoregressive distributed lag (NARDL) model that has suggested the asymmetric patterns of returns among the oil prices and returns of Kuwaits equity market. Empirical results also concluded that short term asymmetric effect exists in the case of WTI Index while no asymmetric pattern has been observed in the case of Brent index in statistical results. Bass (2017) has studied that oil prices linkages with Russian stock market returns by using the GARCH-in Mean approach and vector autoregressive model on weekly data from 2003 to 2017. In the study, it is mentioned there is a positive and significant spillover of the risk from the crude oil market to equity market returns. It is also disclosed that the equity market response towards positive or negative oil price fluctuations is asymmetric.

Shaeri and Katircioglu (2018) have checked the nexus of oil prices with stock market returns of listed companies (technology, transportation, and oil companies) in the US equity market for the sample period of 1999 to 2015 by applying cointegration analysis. The findings of the study indicate the long-term strong association of crude oil market with stock returns of the considered sectors of US stock exchange. It also has been concluded in the study that crude oil prices have a greater influence on oil-related companies as compared to the technological and transportation sectors and the study further provides evidence that in the financial crisis period this nexus is unstable. Eraslan and Ali (2018) analyze the transmission of risk from crude oil market and equity market returns of net oil importers (Brazil, China, France, Germany, Italy, Japan, the UK, and the US) and net oil exporters (Canada, Mexico, Norway, and Russia) for sample period from 1995 to June 2017 by adopting AR(1)-GARCH(1,1) BEKK model. The study documents that returns of the considered equity markets are greatly influenced by the demand side socks as compared to supply-side shocks in. Moreover, it has also been mentioned that this correlation fluctuates over the period depending upon demand and supply shocks.

Anh, Phuoc and Phuong (2018) conduct a study to assess the association among the crude oil price and Vietnam by utilizing the cointegration model in which findings of the study reveal the long term association of the returns of the crude oil with the Vietnam equity market returns in the given sample period however this study does not find any cointegration between two series of data which means that crude oil effect is unidirectional on Vietnam stock market returns. This study also indicates that crude oil price can influence the Vietnam stock indices in positive or in negative ways because there is a balance between damages and profits occurred due to crude oil prices. Kamran, Teng, and Khan (2019) have checked the asymmetrical influence of oil prices on equity returns of shanghai stock exchange by using ARDL model find that if prices of oil increase there is a negative effect on shanghai equity market both in the long and short-run and if there is the reduction in the oil prices the Shanghai equity market will be positively affected. Singhal, Choudhary, and Biswal (2019) have studied the relationship of the crude oil market, exchange rate and equity return of Mexico by deploying a cointegration model, the findings of the study indicate oil prices have negatively affected the equity prices of Mexico in long run.

Wei, Qin, Li, Zhu, and Wei (2019) have applied the nonlinear threshold cointegration to assess the influence of the oil price fluctuation on Chinese equity market prices and Chinese equity market has an association with crude oil prices in the long run, however, this connection is disturbed two times in 2008 and 2012. Jie (2019) have investigated the linkage of the crude oil market with Sino-U.S. equity Market in the course of the trade war by using BEKK model and VAR model in which no significant evidence of return spillover among the crude oil and Sino-U.S. Stock Market is found, however, there are pieces of evidence for the risk transmission from the crude oil market to Sino-U.S. Stock Market and weak in case of the Chinese equity market. The study has further highlighted the time-varying association of the crude oil market with the Sino-U.S. Stock Market in different time regimes.

Finta and Tourani-Rad (2019) conduct a study to check the transmission of volatility from the crude oil market to equity market returns of the US and Saudi Arabia by applying structural VAR methodology. In which it has been concluded that the crude oil market indirectly affects the Saudi Arabian stock market returns. Also, it has been concluded that this spillover follows the asymmetric pattern between the crude oil market and Saudi Arabian equity market returns.

Liu, Ding, Zhai, Wu, and Zhang (2019) revisit the relationship of global crude prices with Chinese ((INE market) stock market returns by deploying GARCH models. It has been concluded in the study that there is strong evidence of bilateral transmission of mean and volatility between INE and international benchmarks. And high time-varying correlation is observed between the considered markets. Kondoz, Bora, Kirikkaleli, and Athari (2019) have tested the transmission of risk from crude oil prices into the equity market returns of US stock exchange (S&P500 index) by applying univariate GARCH and multivariate GARCH (BEKK-GARCH) models. It has been documented that when the univariate GARCH model is applied there is a bidirectional volatility transmission from crude oil market to S andP500 index and when a multivariate GACRH BEKK model is applied there is a unidirectional spillover of risk from S andP500 to the crude oil market.

From the above-mentioned discussion, it can be concluded that crude oil market influences the equity market of different countries in short or long terms and risk transmission process also exists in some countries. It is also proven in reviewing the previous studies that ARMA-GARCH (1,1) and vector autoregressive model is best approach to capture the short- or long-term nexus and risk transmission process.

2.2 Time-Varying Correlation between Crude Oil Market and South Asian Equity Markets

The relationship between different financial assets does not remain the same. Different economic factors can disturb this relationship at different times. There is also a necessity to check the time-varying correlation between different financial assets to address this problem. Several researchers like Chang, McAleerc and Tansuchatf, (2012), Robiyanto, (2013), etc. and Antonakakis and Files (2103) have utilized the DCC and ADCC GARCH models to check the time-varying volatility associated with different financial assets and suggest that the DCC and ADCC methodologies are appropriate for measuring the time varying linkage between different financial assets. This section reviews the literature related to time-varying correlation among the crude oil market and other equity markets of different countries. Tansuchat, Chang, and McAleer (2010) have also checked the conditional correlational of FTSE100, NYSE, Dow Jones, and S and P500 index by utilizing the VARMA GARCH model and DCC models. The findings of this study indicate that parameters of conditional correlation across the market are week and some are insignificant. It is indicated that stability condition does not meet which violate the supposition of constant conditional correlation. However, surprisingly VAR- GARCH model has provided evidence of transmittal process of the risk from crude oil to considered equity market prices.

Ghorbel, Abbes, and Boujelbene (2012) have observed the risk transmittal mechanism and dynamic conditional correlation among crude oil and equity market returns by deploying the BEKK-GARCH model, the CCC-GARCH model, and the DCC-GARCH model. The findings of the study indicate the significant spillover of the volatility from the crude oil market to oil-importing and exporting equity markets which confirms the statistical results of the previous studies in this context. In the conditional correlation is considered it has been observed in this study that conditional correlation across the markets is on the lower side which highlights that shocks are only interlinked in the same domains, not across the domain. This study further concludes that time-varying nexus in oil-importing and exporting countries is not different. Valdes, Vazquez, and Fraire (2012) have explored the time-varying conditional association among the oil market and equity market returns of Mexico stock exchange by using the BEKK model which indicates the shreds of evidence of positive time-varying conditional correlation in the considered markets. However, few companies show the negative movements in conditional correlation.

Robiyanto (2013) have modeled the study to check The Dynamic Correlation among the ASEAN-5 Stock Markets (Indonesia, Singapore, Malaysia, the Philippines, and Thailand) and World Oil Prices by utilizing the Dynamic Conditional Correlation- Generalized Autoregressive Conditional Heteroscedasticity (DCC-

GARCH). The results indicate that the time varying nexus among the crude oil market and the Major Asian market is not significant, however, it changes according to respective equity market dynamics and commodity market conditions. Antonakakis and Filis (2103) examine the time-varying nexus by using the DCC GARCH model on five equity markets in which oil importers (the US, UK, and Germany and oil exporters (Norway and Canada) are used as a sample area. In this study, findings suggest that the time-varying correlation among crude oil returns changes and equity market returns is not constant during the sample period. It does not matter that the country is a major importer or exporter, these two variables depend on the status of the economy. Demand-side shocks negatively affect the correlations however supply-side shock does not influence the returns of the equity market of these economies.

Guesmi and Fattoum (2014) have conducted a study in the context of oil-importing and exporting countries by applying the DCC GARCH model in which it has been concluded that equity markets are closely interlinked with crude oil returns. The study further indicates that in the case of oil-importing countries demanded related shocks created in the oil market determines the equity prices and in the case of oil-exporting equity prices of these countries are driven by supply-related shocks. Muhammad, Akhtar, and Sultan (2015) by using BEKK-GARCH check the time-varying and spillover reaction of the oil market on equity markets of Pakistan and find the significant transmission of risk associated with the crude oil prices to the returns of the equity markets of Pakistan. The effect of these shocks changes with the passage of time according to changes that happen in the crude oil market. Aimer (2016) models a study to check the Conditional Correlations and risk transmittal mechanism among the Crude Oil and Stock Index Returns of Golf countries by employing BEKK-GARCH, DCC-GARCH models. In a study, the statistical results report there is the transmission of uncertainty from the WTI index to oil-importing and exporting indexes. The outcomes of the study further disclose that there is presence of a conditional correlation in the examined markets. This time-varying conditional correlation does not different in oil-importing and exporting countries.

Guesmi, Boubaker, and Lai (2016) have checked the time-varying linkages by applying the BEKK GARCH model of the crude oil and the CAC40, and the Dow Jones Industrial Average indexes return. Findings suggest that dynamic conditional correlation is at the peak during crisis time however have come to the normal position after the crisis period. (Kumar, Pradhan, Tiwari, and Kang2019) have investigated the association and transmittal mechanism of risk between the natural gas, the crude market, and returns of the equity markets of India using multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) model and VARMA-DCC-GARCH models. The findings of the study report no cointegration in the crude oil returns and equity market returns of India. DCC models also disclose that the presence of asymmetric effects in examined Markets. Which means that good news influences more than the bad news.

Joo and Park (2016) have observed the time-varying nexus among the oil and equity prices by applying the DCC GARCH model on US, Japan, Korea, and the Hong Kong equity market in which empirical results disclose that there exists a negative time-varying connection in the crude oil market and stock returns. Singhal and Ghosh (2016) have constructed a study to assess the time-varying linkage in the global crude oil price, metal and other equity returns in India by utilizing the VAR-DCC-GARCH framework, which has suggested that there is no direct transmission of risk from crude oil market to Indian equity market returns at the aggregate level. Anyhow, spillover results are significant in the case of the auto sectors, power sectors, and finance sectors. Parameters of conditional correlation are significant which is the evidence of time-varying linkages in the crude oil market and Indian equity market.

Jiang, Jiang, and Mo (2016) by deploying the DCC-GJR-GARCH model has studied the interlink among the international oil prices and Chinas commodity market at the industry level finds that significant evidence of the transmittal process of the returns and risk from oil market to china commodity market returns. Boldanov, Degiannakis, and Filis (2017) study the time-varying relationship by the DAIG BEKK model in the crude oil market and oil-exporters and importer countries. The findings have disclosed that time varying association moves in both positive and negative ways. Jammazi, Ferrer, Jareno, and Shahzad (2017) have explained the time-varying causal connection in the crude oil and equity market returns of six major countries which import the oil (France, Germany, Italy, Spain, the UK, and the US) by utilizing the multi-scale framework (wavelet analysis and causality analysis). The findings section of the study indicates the bidirectional significant time-varying relationship between examined markets in different periods for all countries. Maghyereh, Awartani, and Tziogkidis (2017) conduct a study by deploying the DCC-GARCH model to check the strong connection and spillover from the oil market to Gulf Corporation council countries in which findings indicate that there is strong evidence of risk and returns spillover between crude oil market and considered equity markets. The findings of the study have also highlighted the week conditional correlation among the oil market and the equity market of GCC countries.

Nadal, Szklo, and Lucina (2017) investigate the time-varying linkages by employing the DCC GARCH method for the period 2006 to 2016 on the WTI index and S&P500 index. statistical results indicate that the linkage in the returns of crude oil and returns of the equity market is significantly influenced by demand related shocks. In the case of supply driven shock, it has a week influence on the association of the crude oil market and equity market returns. Bein (2017) has constructed the study to assess the Time-Varying linkage and uncertainty transmission from the Oil market into Stock Markets in the Baltics and Four European Countries by utilizing the econometric DCC-GARCH model. In this study the author report that Baltics have a less time-varying correlation with international oil prices. Results further reveal that the transmittal mechanism of risk from oil market Baltics is much lower than in other European countries. Statistical results also report that the nexus among the oil prices and oil-exporting is on the higher side as compared to the main importers of the oil and there is significant risk transmission in both types of countries from the crude oil market.

Chen, Li, and Jin (2018) examine the of effect the oil prices on the Chinese equity market (energy sector) by deploying BEKK, DCC, and CCC models. The outcomes of the study disclose the significant return and risk convenience from the oil prices to Chinese new energy prices. However, time correlation shows the fluctuation in the given sample period sometime this relationship is strong and sometimes it is at his low level during the sample period. Awartani, Javed, Maghyereh and Virk (2018) by employing the statistical framework DCC-MIDAS (Dynamic Conditional Correlation-Mixed Data Sampling) to check the linkage among the oil prices and equities of MENA countries in which the statistical results proposed that if the oil prices increase over the time it will reduce the risk of Saudi stock market returns but it will increase the volatility in other markets. Risk spillover from the oil market to MENA countries is week. Conditional linkages among the considered market are not positive during the sample period. it changes the sign over time. However, the relationship becomes stronger when the oil prices decrease in a high volatility period. It is also reported that sometime this short term associated convert into long term association particularly in Turkey and Egypt.

Reviewing the literature about time varying nexus in crude oil market and different equity markets it can be summerized that the nexus among crude oil market and different equity markets changes with the passage of time. For measuring this phenomena DCC & ADCC approach is widely suggest by different authors to capture time varying correlation in different financial assets.

2.3 Dependence Structure between Crude Oil Market and South Asian Equity Markets

The trend for modeling the dependence structure between financial assets by applying the copula approach has increased tremendously in the last decade. Different researches have applied this approach like Ning, (2009) have applied the copula approach to determine the dependency of the equity market and the foreign exchange market similarly Basher, Nechi and Zhu (2014) have used the same approach to check the dependence patterns in the equity markets of Gulf countries. The literature regarding the dependence structure among the crude oil market different equity markets is discussed in this section.

Jondeau and Rockinger (2006) have conducted a study to assess the average and extreme dependency of the oil and four big equity markets of the United States, Canada, Europe, and the Pacific region less than Japan. The findings of the study reveal the strong tailed-ness among the crude oil market and these considered markets. The dependence patterns of the Oil prices and Gold Prices Shock on equity market of Iran have been studied by Ofoghi (2012) by deploying Copula methodology in which it has been concluded that dependence structure exists among oil market and Tehran stock exchange returns because Clayton copula has described the lower tailed-ness among crude oil market and Tehran stock exchange returns which means that as the crude oil prices decrease the returns of Tehran equity market also decrease in response.

Najafabadi, Qazvini, and Ofoghi (2012) conduct a study to check the effect of the Shocks created in the Oil and Gold market on the equity market of Iran by applying Copula methodology in which it is suggested that the oil prices significantly affect the returns of Tehran equity market. Which means that there exists a dependent structure among the crude oil market and the Tehran equity market. Clayton copula is the best-fitted copula in this study which indicates the lower tail dependence between the considered markets. It means that if the prices of the crude oil market move downward then the performance of the Tehran equity market will also shift on the lower side. Nguyen and Bhatti (2012) by using the copula approach have checked the dependency among the returns of the crude oil and equity market returns of China and Vietnam. The outcomes of the study have indicated the left tailed-ness among the international oil returns and equity market returns of Vietnam while in the case of the Chinese equity market the right tail dependence with the global prices of crude oil.

Zhu, Li, and Li (2013) have modeled the dependency of the returns of the Asia-Pacific stock market with crude oil prices by employing the copula approach. The statistical result shows the week dependence pattern among oil prices and equity market returns of the considered markets. This dependence structure was positive in Asian pacific countries except for Hong Kong. The study also reveals that this dependence structure was lower tail dependence before financial crises and after the financial crisis, it has been moved to upper tailed dependence. Boubaker and Sghaier (2013) have conducted a study to analyze the dependence structure among crude oil returns and equity markets of the GCC countries by Archimedean copulas (Gumbel, Clayton, and Frank) that capture several dependence structures. In which it has been mentioned that there exists an asymmetric dependency among oil returns shifts and equity market returns. All countries exhibit the left tailed-ness while in the scenario of Oman there is right tail dependence. However, during the financial crises period changes in dependence structure have been observed. The study which is conducted by Naifar and Al Dohaiman (2013) which mentions that the dependency among the crude oil returns and equity market returns is asymmetric, positive, and displays right tailed-ness.

Aloui, Hammoudeh, and Nguyen (2013) employ the time-varying copula approach to conduct a study to capture the dependency of crude oil and equity market in transition economies and find the positive tailed-ness among the oil prices and the equity market returns of the six CEE countries which indicates integration in the considered markets, it also indicates the lower tail dependence among the considered markets which has greater influence as compared to upper tailed-ness. It also explains that in extreme financial crisis conditions such as current financial crises oil and CEE countries equity markets do not provide any diversification benefit, they suggest that investors cannot make the portfolio of these equities to reduce the systematic risk.

Zohrabyan, Leatham, and Wu (2014) have studied the interdependency among the crude oil market and equity market returns by deploying a copula approach in which it has been suggested that there is a week dependence structure among the oil market and equity market returns. However, major importing and exporting countries like the United States and Canada relatively displayed a strong dependence structure with crude oil market returns. Reboredo (2014) has also checked the dependence patterns of the oil prices and renewable energy stock prices by utilizing the copula approach in which findings of the study have concluded that there are time-varying and systematic dependency among the returns of the oil market and many major renewable energy equity market returns. This study has also shown the consistency which previous researches that this dependence structure is not stable over time. Salma (2015) has explored the Uncertainty associated with the Crude Oil Price and Equity Markets of the Gulf Corporation Countries by developing the VAR-GARCH copula model. Which findings provide evidence of the dependency among the crude oil market and returns of the equity markets of Golf Corporation Countries. Findings also indicate the upper and lower tailed-ness between the considered markets. Findings also provide evidence of risk and return transmission from the crude oil market to considered equity markets.

Aloui, Gupta, and miller (2015) have constructed a study with the title of uncertainty and crude oil returns in which copula function is deployed to check the dependency of the crude oil market, economic policies, and EMU and EPU indices. In which the study explains the positive dependence between random variables. Findings interestingly also indicate the strong negative dependence structure in the great recession period. Gatfaoui (2015) has studied the dependence patterns of oil and gas markets with the US stock market by developing the copula estimates in which it is reported that there is the presence of dependency in the oil prices and US stock markets. However, this dependence structure is not stable over time which makes the forecasting process difficult. Chen and Xin (2015) by using dynamic Markov Regime Switching Copula (MRS-Copula) and find the positive dependency among crude oil and equity market reruns and they also have explained that in 2008 financial crises level of dependence has increased among the stock market and oil prices in extreme values. But after the crisis period, larger dependence is not observed.

Jammazi and Reboredo (2016) have studied the dependency and process of managing risk in the oil and equity markets by developing wavelet-copula analysis (includes the functions of time-varying copula). The empirical findings of the study reveal the existing of dependency among the oil market and the equity market. It also exhibits that the dependence structure was a week before 2008 but has become stronger over the period. Results also produce the evidence of asymmetrical tail dependency over the long run before 2008 and upper and lower tailed-ness thereafter. Lai (2016) has modeled the study to assess asymmetric dependency patterns in oil and stock prices by using a copula approach. Statistical results have revealed the presence of the asymmetrical dependence patterns in the crude oil market and the major international equity markets. However, this dependence structure is different in the different periods, in the different equity markets, in financial situations and the context of oil-importing and exporting countries. Kayalar, Kucukozmen, and Selcuk-Kestel (2016) find that equity markets of several countries like Turkey are positively dependent on the crude oil tariffs and high dependence is observed in those countries that export energy, however, developed importing countries showed lesser dependence.

Aloui and Aissa (2016) examine the dependency among the oil, equity prices, and exchange rates by deploying vine copula-based GARCH approach on WTI crude oil, the 29 Dow Jones Industrial Average stock index and the trade-weighted 30 US dollar returns index and report the significant asymmetrical dependency in the crude oil market and stock markets. However, this dependent structure is not constant in giving sample period. Outcomes of the study also indicate that this dependence patterns is disturbed during the crisis period from 2007 to 2009. It is also discussed in this study that the vine copula approach improves the VAR estimates. Mensi, Hammoudeh, Shahzad, and Shahbaz (2016) perform a study to model systematic risk and forecast the dependency of the oil and equity markets by deploying the variational mode decomposition-based copula method in which empirical findings reveal there is tail dependency in the crude oil returns and S&P100 equity market. The study concludes that there exists an average pattern of dependence in the case of short-run and data series also exhibits the long-run dependence structure between the market. Statistical results provide strong evidence of bilateral up and down transmission of risk from the crude oil market and stock market returns.

Arfaoui and Rejeb (2017) examine the interdependency among the Oil, gold, US dollar, and stock market by using the simultaneous equation approach. Findings of the study disclose the significant linkage between every market however the negative dependence has been observed among crude oil market and equity markets. Mejdoub and Ghorbel (2017) have constructed the study to check the

Conditional dependency among the oil price and equity prices of the renewable energy by deploying a vine copula approach in which findings of the study reveal the symmetric and significant tail dependence patterns exists in the considered markets. Evidence also indicates the upper and lower tailedness among the considered markets. This means that the indices of both markets react in the same manner.

Hamma, Ghorbel, and Jarboui (2018) have studied the dependency patterns in the oil prices and equity markets of Egypt and Tunisia by employing a copula model in which statistical findings have reported the significant and symmetrical tailed-ness in global crude oil returns and equity market prices. However, this tail dependence changes over time. This study indicates a high level of volatility due to rapid changes in oil prices. Zhao, Ji, Liu, and Fan (2018) model the dependency of the oil price shock and equity price returns in BRICS countries by using Time varying Copula and structural VAR models. The study reports that the nature of the dependency in the oil price shocks and equity market returns depends on the nature shocks created in the oil market and it fluctuates over time. The study also provides evidence of volatility transmission from the crude oil market to stock market returns and it also shows the asymmetric patterns and transmission of downside risk from the oil market to equity market return has been observed in the case of BRICS countries.

Li and Wei (2018) have modeled the dependency and transmission of risk from the crude oil market and equity market of China by using variational mode decomposition-based copula method and findings indicate the recent financial crises have increased the dependency among the crude oil market and equity market of china. Outcomes of the study also reveals that dependency, in the long run, is much stronger than dependency in the short run. The study also explains the asymmetric patterns in the dependence structure. Wen, Bouri, and cheng (2019) have conducted a study by using switching copulas and time-varying single copulas to show the positive linkage between crude oil and stock market indices of emerging markets and regression analysis indicates oil return volatility, countries specific variables. US policy uncertainty has a positive influence on stock-oil dependence but the strong US economy pushes downside the dependence structure of the oil and equity market. Karakas (2019) have assessed the dependence structure among the crude oil market prices and stock market returns of Istanbul stock exchange by using COPULA-GARCH APPROACH in which findings have indicated the week dependence structure among the Brent crude oil index returns and Istanbul stock market returns. This study has also indicated that negative conditions are more effective than positive conditions in serial.

Mokni and Youssef (2019) have also explored the consistency in the dependence structure among the crude oil returns and GCC equity markets by using a copula model. Empirical findings have indicated the positive but persistent association among the returns of the crude oil and GCC equity market returns. It is also concluded that the Saudi Arabian equity market has shown a high level of persistent dependent structure with prices of oil. In this study, it is also mentioned that after the financial crisis of 2014 this dependence structure has increased tremendously. This study indicates the upper tailed-ness as compared to lower tailed-ness in the considered markets. Kouki, Masoud, and Barguellil (2019) perform a study to check the Dependence structure among the Oil Prices and Equity Market Returns by using Copula-GARCH estimates in which it has been concluded that there is strong evidence of tail dependence between the considered market in an unstable financial environment.

Ferreiro (2019) has combined the copula model with Switching Markov models to assess the linkage of the oil prices with European stock markets. in which it has been found that there is lower tail dependence from negative to a positive connection in the crude oil market and European equity markets. It is also concluded that this dependence structure follows the asymmetric patterns.

From this section it can be concluded that dependence patterns also exist in different equity markets. For measuring these dependence patterns different authors suggest the copula approach. As this technique is widely used in different studies,so, it is proven that estimates of this technique are much accurate and more consistent.

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From above-mentioned literature following hypothesis are developed:

H_1: *Crude oil prices have a significant impact on the return of South Asian countries.*

H_2: *There is a time-varying linkage among the crude oil market and South Asian Equity markets.*

H_3: *There is a dependence among the crude oil and equity market.*

H_4: *The dependence structure between the crude oil market and equity market the at left tail and the right tail is the same.*

Chapter 3

Data Description and Methodology

The methodological section of the study is divided in three parts. In the first part ARMA-GARCH model and Vector Auto Regressive models are discussed and in the second part DCC & ADCC-GARCH models are discussed and in third portion different copula functions are discussed which are utilized to capture the dependence structure of crude oil prices and equity market indices of South Asian countries.

3.1 Data Description

The study utilizes daily returns of WTI index (West Texas intermediate) and equity market returns of South Asian countries (India, Pakistan, Srilanka, and Bangladesh).Other South Asian Countries like Afghanistan, Nepal,Bhutan and Maldives are dropped because the size of their economies is small and no logical comparison can be made. Closing prices of WTI index and stock market prices of South Asian countries (India, Pakistan, Srilanka, and Bangladesh) are used from January 01, 2004, to June 30, 2019. The fact behind the usage of daily prices is that the financial market usually follows extreme co-movement immediately. Crude oil prices of WTI index are considered as an independent variable and whereas indices of South Asian Stock markets are considered as dependent variables. For empirical analysis purpose, daily data is transformed into the log-returns by using this formula rt=LN(P_t/P_{t-1}) whereas Pt is the price at the end of the day t, P_{t-1} is the price at the end of the day t-1 and R t is the return of the end of the day t.

3.2 Methodology

The statistical analysis section begins with the devising of the return series of the different equity markets by adjusting ARMA-GARCH models to the data and taking out the residuals of these return series then the marginal distribution function is applied to those residuals. Once the best fit model has been selected by using AIC Criteria, the five copula functions Gaussian, Students t, Clayton, Frank, and Gumbel, are used to assess the dependency among returns of the south Asian equity market and crude oil. For justification of the efficiency of the dependency patterns of the random variables, Spearmans correlation and Kendals Tau are used.

3.2.1 The Returns and Spillover Analysis between Crude Oil Market and South Asian Equity Markets

ARMA (p, q) -GARCH (1,1) model is applied to conduct the spillover analysis which is mostly used in financial data to forecast the returns and volatility transmission among the return series. On one hand, this blend allows us to identify volatility, clusters, time-varying volatility and on the other hand, it calculates independent and identical residuals that provide further assistance for further analysis. ARMA (p, q)-GARCH (1,1) can be written in the following manner.

The GARCH (p, q) equation is

$$\sigma_t^2 = \lambda_0 + \sum\nolimits_{t-1}^{p} a\sigma_{(t-1)}^{p} + \sum\nolimits_{t=1}^{p} \beta\varepsilon_{t-1}^2 \tag{1}$$

σ_t^2 is used for variance, ε_t for return series, and λ_0 is deployed for the constant term. For the persistence of the volatility and stationery of data alpha + beta < equal to 1. Long-term variance for the considered market is calculated as

$$r_{c,t} = \mu_0 + u_1.r_{c,t-1} + \mu_2.v_{c,t} + \mu_3 \cdot_{c,t-1} + _{c,t}, _{c,t}N(0, v_{p,t}) \tag{2}$$

$$\nu_{(c,t)} = \phi_0 + \phi_1.u^2_{(c,t-1)} + \phi_2.\nu_{(p,t-1)} \tag{3}$$

Where $r_{c},_{t}$ represents the daily prices of the crude oil market at time t and $\varepsilon_{c},_{t}$ is used to represent error term or residual value

3.2.2 Vector Auto Regressive Model (VAR)

In this study short- and long-term relationship among crude oil market and the South Asian equity market is estimated by applying the Vector Auto-regressive (VAR), model. VAR model is utilized for estimation for long term relationships between the data when the data is stationary and contains no unit root. For the stationary purpose, the returns series are plotted into graphs that report the returns series of every market meets the assumption of stationarity. For testing the unit root between the return series, this study uses the ADF test which is reported in the results and discussion part, and provides the evidence of no unit root between different return series. This study also intends to explore the nexus among crude oil market and South Asian stock market returns by deploying a Vector Auto-regressive model. So, the VAR equation is written as follows.

$$CO_{t=}\alpha_0 + \alpha_1 crudeoil_{t-1} + \alpha_2 pakistan_{t-1} + \\ \alpha_3 India_{t-1} + \alpha_4 Srilanka_{t-1} + \alpha_5 Banladesh_{t-1} + \varepsilon_{t-1} \tag{4}$$

$$Pakistan_{t=}\beta_0 + \beta_1 crudeoil_{t-1} + \beta_2 Pakistan_{t-1} + \\ \beta_3 India_{t-1} + \beta_4 Srilanka_{t-1} + \beta_5 Banladesh_{t-1} + \varepsilon_{t-1} \quad (5)$$

$$India_{t=}\lambda_0 + \lambda_1 crudeoil_{t-1} + \lambda_2 pakistan_{t-1} + \\ \lambda_3 India_{t-1} + \lambda_4 Srilanka_{t-1} + \lambda_5 Banladesh_{t-1+}\varepsilon_{t-1} \quad (6)$$

$$Srilanka_{t=}\gamma_0 + \gamma_1 crudeoil_{t-1} + \gamma_2 pakistan_{t-1} + \\ \gamma_3 India_{t-1} + \gamma_4 Srilanka_{t-1} + \gamma_5 Banladesh_{t-1+}\varepsilon_{t-1} \quad (7)$$

$$Bangladesh_{t=}\delta_0 + \alpha_1 crudeoil_{t-1} + \delta_2 pakistan_{t-1} + \\ \delta_3 India_{t-1} + \delta_4 Srilanka_{t-1} + \delta_5 Banladesh_{t-1+}\varepsilon_{t-1} \quad (8)$$

3.2.3 Time-Varying Linkage between Crude oil Market and South Asian Equity Markets

ARMA GARCH and VAR model assumes that correlation among the random variable is constant over time but this correlation may variate over time. When stocks of different markets move in the same manners then the relationship among variables expands marginally and when two stocks shift in the opposite direction then the correlation among variables decreases. It is assumed that the relationship between random variables temporarily deviates from its average line. So, for this possibility, the DCC-GARCH model is used to estimate the time-varying linkage between variables, and asymmetric behavior is captured by using ADCC-GARCH models. DCC model provides evidence of symmetric behavior of higher tail dependency on upper and lower tail dependence and the ADCC model estimates the asymmetric behavior of high tail dependence on the lower tail.

There is the step by step process for the selection of the best-fitted model. Different GARCH specifications like EGARCH, GJRGARCH, and GARCH models are used for modeling the time-varying correlation between random variables. The best-fitted model is favored on the basis of the Akaike Information Criterion (AIC). The model which shows minimum AIC value is selected for observing the time-varying relationship among random variables.

The DCC-GARCH econometric model mathematically can be defined as follow.

$$Q_{(t)} = (\bar{}_{R}) + \sum_{(i=1)}^{m} \pi_i(\in_{(t-i)}\in_{(t-i)} - (\bar{}_{R})) + \sum_{(i=1)}^{m} \in_i(Q_{(t-1)}\,\bar{}_{R}) \tag{9}$$

ADCC GARCH model can be defined as follows

$$Q_t =\bar{}_{R} + A.(\in_{(t-1)}\in^*{}_{t-1} - \bar{}_{R}) + B.(Q_{(t-1)} - \bar{}_{R}) + G.(\sigma_t\sigma_t - \bar{}_{N}) \tag{10}$$

3.2.4 Copula Models for the Dependence Structure

Firstly, copula functions are proposed by Sklar (1959) now became an influential tool for modeling the dependency of the random variables. The usage of the copula functions increased tremendously over the last two decades. Several studies have applied copula function to determine the dependence structure in financial data for better results. Copula function can be defined in this way, the copula is a function that ties an n-dimensional aggregate distribution function to its single-dimensional margins and is alone a constant distribution function describing the dependency of the model. So according to Sklar, joint distribution between variables can be explored in copula form by transforming the marginal distribution into a uniform distribution. So, any collective distribution can be transformed into marginal distribution. The equation for this process can be written as follows.

$$F\left(F1\ldots,F_k:\theta_1\ldots\ldots\ldots\theta_{k,\delta c}\right)\ =C(F\left(X_{1,}\theta_1\right)\ \ldots\ldots,F\left(X_{1,}\theta_{k);}\delta_c\right) \tag{11}$$

Where $X_{1....}$ Xkdenotes random variables of joint distribution F and C is used to display Copula function. $\delta_c$is usedfor copula parameters and $\theta_1\ldots\ldots\ldots$ $\theta_k$represents the marginal distribution's parameters.

The study aims to capture the dependence structure by employing the bivariate copula approach. In which it is assumed that all joint distribution is differentiable. The join bivariate joint distribution can be written as

$$(X_1,X_2,\theta_{1,}\theta_{2,}\delta_{c)}=\vartheta^2(F_1\left(X_1;\theta_1\right),F_2\left(X_2;\theta_2\right);\delta_c/\vartheta X_1.\vartheta X_2 \tag{12}$$

$$f(X_1,X_2;\theta_1,\theta_2,\delta_c)=C(F_1(X_1,\theta_1),F_2(X_2,\theta_2);\delta_c).\Pi^2_{(k=1)}fk(x_{(k;)}\delta_c) \tag{13}$$

If C (u_1, u_2; δ_c= ϑ ^{2}C (u $_1$, u $_2$, δ_c)/ ϑu_1. ϑ $u_2$then distribution function X_1 and X_{2is} the outcome of copula functions and the two-marginal distributions $f_1(x_1;\theta_1)$ and $f_2(x_2;\theta_2)$. The log likelihood can be written as

$$Logf(X_1,X_2;\theta_1,\theta_2,\delta_c)=logc(f1(X_1,\theta_1),F_2(X_2,\theta_2);\delta_c)+\sum_{(k=1)}^{2}logf_{(k)}(x_{(k)};\delta_c) \tag{14}$$

$$L(\theta_1,\theta_2,\delta_c)=LC(\delta_c)+\sum_{(k=1)}^{2}lk(\theta_k) \tag{15}$$

L_k and Lc describes the log-likelihood function of the copula and X_k

Copula parameters are calculated by using inference functions of the margins which are developed by Jeo&Xu (1996). The inference functions of the margins provide the consistency and asymptotically normally distributed. This method is widely used by the researcher to calculate the copula parameters. IFM procedure follows a two-step process for forecasting purpose of copula parameters.

In the first stage for estimation purpose the maximum log-likelihood is used to estimate the parameters of the marginal distribution. Which can be written as follows

$$\theta_1 = arg\, max \sum_{(t=1)}^{T} logf_1(x_{(1,t;\theta_1)}) \tag{16}$$

$$\theta_2 = arg\, max \sum_{(t=1)}^{T} logf_2(x_{(2,t;\theta_2)}) \tag{17}$$

Secondly, we apply the parameters which are calculated in the first step to determine the copula parameters.

$$\delta_c = argmax \sum_{(t=1)}^{T} logC(\mu_{(1,t;\delta_c)}) \tag{18}$$

After the estimation of copula parameters, the best copula is selected which describe the pattern of dependence structure. Different researchers have used different selection criteria for model selection. This study applies the Akaike Information Criterion (AIC) technique for selection. The copula which contains the minimum AIC value is preferred for interpretation purposes. AIC can be defined as follows.

$$AIC = -2(log - likelihood + K) \tag{19}$$

Whereas k is used to denotes the enumeration purpose of the parameters that are used in the model.

3.2.5 Bivariate Copulas

Defining the dependence structure between random variables is a complex process because of asymmetric behavior in financial data. For avoiding this complexity, this study applies the bivariate approach of copula to determine the dependence structure between random variables. Bivariate function is consisting of the elliptical copula (Gaussian copula and student-t copula) and Archimedean copula (Clayton copula and Gumbel copula). Elliptical copula is used to determine the symmetric dependency on both tails while Archimedean copula is used to describe the lower and upper tail dependence between random variables.

Different bivariate copulas which are established to ascertain the dependence structures between the crude oil market and South Asian equity markets are defined as follows.

3.2.5.1 Bivariate Gaussian Copula

The Gaussian copula is the unit cube distribution. It is calculated from a multivariate normal distribution by utilizing the probability integral transformation. The Gaussian copula mathematically could be characterized as follows.

$$C^{Gauss}\left(u\right) := \Phi P \;\; \Phi^{-1}\left(u_1\right), ..., \Phi^{-1}\left(u_d\right) \tag{20}$$

$$C\left(u, v\right) = \int_{-\infty}^{\emptyset-1(u)} \int_{-\infty}^{\emptyset-1(u)} \frac{1}{2\pi\sqrt{1-\delta^2}} exp\left\{-\frac{x^2 - 2\delta xy + y^2}{2(1-\delta^2}\right\} dx.dy \tag{21}$$

3.2.5.2 Bivariate Student T Copula

It talks about the linear coefficient of correlation and the degree of freedom is less than 30. Student t copula has more in tails then Gumbel copula.This copula function exhibits the dependence between random variable on both tails. It can be elaborated as follows

$$C^t\left(u, v; \delta\right) = \int_{-\infty}^{t_v^{-1}(u)} \int_{-\infty}^{t_v^{-1}(v)} \frac{1}{2\pi.\sqrt{1-\delta^2}} \left\{-\frac{x^2 - 2\delta xy + y^2}{2\left(1-\delta^2\right)}\right\}^{-(v+2)/2} dxdy \tag{22}$$

3.2.5.3 Gumbel Copulas

Gumbel copula is developed by Gumbel (1960). The Gumbel copula is a disproportionate Archimedean copula, shows more dependence on negative tail rather than positive tail. Gumbel copula mathematically can be displayed as.

$$C^{c}\left(u,v;\delta\right)=\exp\left\{-\left[\left(-In\ u\right)^{\ \delta}+\left(-Inv\right)^{\ \delta}\right]^{\ \frac{1}{\delta}}\right\},\delta\in\left(1,\infty\right) \tag{23}$$

3.2.5.4 Clayton Copula

Clayton copula is proposed by Clayton (1978). The Clayton copula is described as asymmetric Archimedean copula, which mostly displays the tail dependence on the positive tail rather than negative tail. Equation for clayton copula can be constructed as:

$$C^{C}\left(u,v;\delta\right)=\max\left\{\left(u^{-\delta}+v^{-\delta}-1\right)^{\ \frac{-1}{\delta}},0\right\},\delta\in\left[-1,\infty\right]\left\{0\right\} \tag{24}$$

3.2.5.5 Frank Copula

Frank copula is the copula which is used for modeling codependency between random variables.

It is also called as an exchangeable copula. It can take a mathematical form as follows.

$$C_{\theta}^{Fr}(u_{1}......,u_{k})=-\frac{1}{\theta}\log\left(1+\frac{\prod_{i}\left(\exp(-\theta u_{1})-1\right)}{\exp(-\theta)-1}\right) \tag{25}$$

If we assume the θ=0 then the limit is used for the interdependence of copula.

All the above mention copula functions capture the various dependence structure from low dependence to extreme dependence which may be either on positive or negative tail or lower and upper tail dependence.

3.2.6 Spearmans Correlation and Kendals Tau

Correlation is the bivariate analysis which measures the direction and strength between variable. The strength may be between +1 and -1. If the value is closer to +1 that indicates the perfect positive nexus among the variable and when the value of the correlation coefficient is closer than -1 then there is a perfect negative relationship between variables. This study considers two correlation tests that measure the relationship between variables. These two non-parametric tests are Kendall; Spearman correlation. Kendall rank correlation is considered as the non-parametric test that is utilized to determine the strength of dependency among variables, however, the Spearman rank correlation is deployed to estimate the degree of association between the variable.

Chapter 4

Data Analysis and Results

This part of the study includes the outcomes of the different tests that are applied to examine the phenomena which are suggested in the methodological section and this section also includes the interpretation of those results.

4.1 Graphical Representation of Data

The first step in every study is to check the behavior of the data by graphical representation. The stationary of the data is checked by the visualization of different series of data. The stationary of data is the initial assumption for conducting the spillover analyses and cointegration analysis. In short, the mean of the series must be constant over the period. Graphs of different series are available in the appendix section as Appendix A which represents the behavior of the data.

4.2 Descriptive Statistics

In the second step behavior of the data is analyzed through descriptive statistics of different series of data which includes the dependent and independent variables. Crude oil is an independent variable and South Asian equity markets are considered as dependent variables which are exhibited in Table 4.1. Table 4.1 includes all important movements which tell about the behavior of the data like Mean, Median, Standard deviation, skewness, and kurtosis. Minimum and maximum levels of responses are used to measure the spread of the data. Closing prices of Crude oil market and South Asian equity markets are considered for statistical testing purpose. The time duration in the case of Crude oil, Pakistan, India, and Srilanka are for 15 years. However, in the case of Bangladesh, it includes 7 years because of the unavailability of daily indices of the Dhaka Stock Exchange which is the equity market of Bangladesh. Average mean returns measure the average performance of different equity markets. Statistical results report that the average performance of the equity markets is positive. However, the highest averages performance is for the KSE-100 which is (.0385%) and lowest means returns performance is shown by the Crude Oil market which is (.0104%). Standard deviation indicates the volatility associated with different markets. Table 4.1 Statistical results indicate that high volatility is attached to the Dhaka Stock market which is 2.7% which logically justifies the risk and return relationship. However, the lowest volatility is associated with the Colombo equity market which is .079% which indicates that this equity market is less volatile as compared to other equity markets of South Asian countries.

Table 4.1: Descriptive Statistics

	Crude oil	**KSE100**	**BSX**	**CSX**	**DSX**
Mean	0.000104	0.000358	0.000335	0.000286	0.000111
Median	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.146993	0.082547	0.159900	0.092731	0.534623
Minimum	-0.129389	-0.060418	-0.118092	-0.111353	-0.527966
Std. Dev.	0.019139	0.010176	0.011541	0.007881	0.027425
Skewness	-0.097478	-0.407601	-0.070651	-0.659071	0.189094
Kurtosis	9.789428	9.106667	19.62979	32.07929	342.9760
Jarque-Bera	10878.09	8949.692	65212.90	199796.3	11279054
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

Note: This table contains estimates related to the descriptive stats of crude oil markets and different South Asian equity markets.

Minimum and maximum values indicate the minimum and maximum returns earned by different markets. The maximum returns earned by the Crude oil market by is 14.69% f and minimum return by the crude oil market is -12.93% which is considered as loss of the market on a date. in Case of KSE100 average returns is .0104% and the maximum return is 14.695% and the loss gained per day is 12.93% and so on. The asymmetric behavior of the data is indicated with the help of the skewness of data. According to statistical results reported in Table 4.1 data is negatively skewed in case crude oil markets, KSE-100, BSX, and CSX and in Case of Bangladesh data is positively skewed. Kurtosis indicates the tailed-ness of the probability distribution of the data. In Table 4.1 All values of the kurtosis are positive and higher than 3 which indicates that series showed leptokurtic behavior. Fat tail with a high peak which is highly affected by equity market bubbles. In the end, it can be concluded that data is not normally distributed as it showed the leptokurtic behavior and as evident from the Jarque-Bera tests statistics.

4.3 Return and Volatility Spillover from Crude Oil Market to South Asian Equity Markets

The second stage of the study discusses the mean and volatility transmission analysis which is utilized to check either South Asian equity market returns are affected by the Crude market or not. For this purpose, series are modeled by the ARMA-GARCH model which is broadly used to forecast the mean and risk spillover among different markets.

4.3.1 Heteroskedasticity Test

It is a preliminary assumption for applying ARCH GARCH models that data should not be homoscedastic. Heteroskedasticity test has been performed on each return series to check whether data is homoskedastic or heteroskedastic. Table 4.2 reports that data is heteroskedastic because the LM statistic is significant. All P-values are less than .05 which is an acceptable standard in research.

TABLE 4.2: Heteroskedasticity Test (LM Stat)

	Crude Oil	**KSE100**	**BSX**	**CSX**	**DSX**
F-Statistics	254.0845	461.5479	81.36845	160.3722	237.3501
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Obs*R-Squared	243.2451	426.8709	80.24263	156.0048	215.6597
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: Note: This table includes the Heteroskedasticity test (LM stats) statistics. And in parenthesis, their P values are mentioned respectively.

4.3.2 Spillover Analysis between Crude Oil Market and South Asian Equity Markets

In this section, the spillover analysis technique is utilized to check the mean and risk transfer from the oil market to South Asian equity markets. Table 4.3 exhibits the results of return and volatility transmission from crude oil markets to South Asian equity markets by using an ARMA GARCH (p&q) models. Coefficients of each ARMA GARCH model are reported with their P values (in parenthesis) respectively.

According to statistical results reported in table 4.3 value of $\mu_{1,}$ is insignificant and positive which means that the return of the South Asian equity markets cannot be predicted by the past price behavior of the markets. The market is efficient in the case of the following equity markets. Portfolio diversification opportunity exists in South Asian equity markets. Coefficients of $\mu_{2,}$are positive and insignificant which means that historical prices of South Asian equity Markets cannot be used to forecast todays returns. In addition, the coefficient of $\mu_{3,}$ is insignificant which means that considered equity markets do not make necessary adjustments based on past price shocks. However past price behavior can be used to predict the volatility of the current period because the coefficient of $\phi_{1,}$ is significant (p-value $<.05$) and positive and coefficients of $\Phi_{2,}$ are also positive and significant which shows the persistence of the volatility. In all considered equity markets persistence of volatility is for the longer time because the sum of the coefficients $\phi_{1,}$and $\phi_{2,}$ is closer than $1(\phi_{1,}+\ \phi_{2,} <1)$ .Return spillover only exists in the case of the BSX

Table 4.3: Spillover Analysis between Crude oil market and South Asian Equity Markets ARMA GARCH Model

	Crude Oil	**KSE**	**BSX**	**CSX**	**DSX**
μ_o	2.285131	0.909384	2.752163	7.665384	6.127201
	(0.0814)	(0.6626)	(0.2157)	(0.0977)	(0.0900)
μ_1	-0.000170	0.000565	0.001012	-0.000167	-0.002749
	(0.6196)	(0.0206)	(0.1042)	(0.8373)	(0.5609)
μ_2	-0.225597	0.201282	-1.044844	-0.016851	-0.057452
	(0.5059)	(0.3772)	(0.3971)	(0.9394)	(0.9298)
μ_3	0.181351	-0.130980	1.056373	0.155918	-0.224244
	(0.5940)	(0.5662)	(0.3923)	(0.4915)	(0.7195)
$\mathbf{\Phi}$		2.21E-06	0.000814	8.50E-05	-0.000483
		(0.9796)	(0.0000)	(0.6890)	(0.8667)
ϕ_0	1.66E-06	2.48E-06	3.40E-07	5.82E-05	0.000510
	(0.0000)	(0.0000)	(0.0044)	(0.0000)	(0.0000)
ϕ_1	0.037767	0.087206	0.054832	0.150000	0.150000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.3101)
ϕ_2	0.958204	0.883863	0.940770	0.600000	0.600000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
λ		7.39E-11	7.88E-11	-6.34E-10	-4.52E-09
		(0.0007)	(0.0000)	(0.0000)	(0.0000)

Note: where KSE indicates the KSE-100 index. BSX for Bombay stock exchange returns, CSX is for Colombo Stock exchange and DSX for Dhaka stock exchange returns, parameters of spillover analysis along with P-values are mentioned. whereas denotes the parameters of mean spillover and denotes the parameters of volatility spillover.

because the coefficient of Φ is significant and positive that indicates if returns of crude oil market changes in the response of that change. The Bombay equity market adjusts their returns in the opposite direction while other south Asian equity markets do not respond if the return of crude oil market changes because the coefficient of these markets are insignificant. Statistical results further report that in case of CSX and DSX coefficients of λ are also significant and positive which indicates that risk transmits from the crude oil market to these equity markets but the volatility of these markets will decrease. In the case of KSE and BSX, coefficients of λ are significant and negative which tells that volatility transmission exists from crude oil market to KSE and BSX but a negative sign indicates that if volatility increases in Crude oil markets then in the response to that change volatility of these market adjust negatively.

4.4 Time-Varying Conditional Correlation DCC and ADCC

It is mentioned in the methodology section that ARMA, GARCH model captures the effect of spillover of one market to another market by undertaking the assumption of Constant conditional correlation. This study also aims to check the time-varying conditional linkage. Then, the dynamic conditional correlation model, the DCC model is used to forecast this effect. However, asymmetric conditional correlation effect has been observed by the extended version of this model that is Asymmetric Dynamic Conditional Correlation ADCC.

4.4.1 DCC - GARCH Models and Estimates Between Crude Oil and South Asian Equity Markets

Table 4.4 exhibits the selected models which are chosen by using the Akaike Information Criteria (AIC) value. According to this assumption followed in research studies about this criterion those models will be selected which shows minimum AIC values.

TABLE 4.4: Best Fitted Models of DCC GARCH Approach

S No	Country Name	Selected Model
1	**KSE100**	univariate EGARCH
2	**BSX**	univariate EGARCH
3	**CSX**	univariate EGARCH
4	**DSX**	univariate EGARCH

Note: This table exhibits the selected DCC GARCH model concerning each equity markets

Table 4.4 indicates that univariate EGARCH models are the best fitted model in the case of all South Asian equity markets because the Univariate EGARCH model displays minimum AIC value as compared to other DCC GARCH models.

Table 4.5 exhibits the statistical estimates obtained by using the DCC GARCH model from the crude oil market to different South Asian equity markets. $\theta_{1,}$ indicates the past residual shocks and $\theta_{2,}$ shows the lagged dynamic conditional correlation and in the parenthesis their P values are mentioned respectively.

According to statistical results reported in Table 4.5 stability condition has been met because sum $\theta_{1,}and\theta_{2,}$ is less than $1(\theta_{1,}+\ \theta_{2,}<1)$. When the stability condition meets it indicate that DCC models are an appropriate econometric model to forecast the time-varying conditional association. In case of KSE 100 and DSX coefficients of $\theta_{1,}$ are insignificant because their P-values are more than 0.05 which indicates no effect of past residual shocks on the correlation however in case of BSX and CSX coefficients of $\theta_{1,}$ are significant and positive which reports that past residual shocks have a significant impact on the correlation.

Table 4.5: Estimates of DCC-GARCH Model

	θ_1	θ_2
KSE 100	0.010047(0.1677)	0.663179(0.0099)
BSX	0.004128(0.0005)	0.994878(0.0000)
CSX	-0.007844(0.0000)	0.534646(0.0951)
DSX	0.011289(0.5828)	0.867887 0.0480

Note: This table contains the estimated coefficients obtained by using the DCC -GARCH model for crude oil market and South Asian equity markets. p-values are mentioned in parenthesis. Theta (1) and Theta (2) are reported above the p-values. The suitable univariate GARCH model is picked on the Akaike Information Criteria (AIC).

Statistical estimates also report that coefficients $\theta_{2,}$ are significant in case of KSE100, CSX and BSX their P values are less than 0.05 which indicates that there exists lagged dynamic conditional correlation in equity markets however in case and DSX $\theta_{2,}$ is insignificant which means that there is no lagged dynamic conditional linkage in these equity markets.

4.4.2 ADCC GARCH Models and Estimates between Crude Oil and South Asian Equity Markets

A time-varying correlation has been analyzed in the previous section by using the DCC model and now by using ADCC model asymmetric conditional correlation is applied. As it is previously mentioned in the DCC section that the appropriate model is selected by using AIC criteria. Same criteria is used for model selection purposed. Table 4.6 exhibits the model selection criteria. The best-fitted model is preferred on the basis of the Akaike Information Criteria (AIC). According to this selection criteria those models are chosen which shows the minimum AIC value.

TABLE 4.6: Best Fitted Models of ADCC GARCH Approach

S No	Country Name	Selected Model
1	**KSE100**	GJR/TGARCH
2	**BSX**	GARCH
3	**CSX**	GJR/TGARCH
4	**DSX**	GJR/TGARCH

Note: This table exhibits the selected ADCC GARCH model concerning each equity markets and then the appropriate model is preferred based on the lowest possible Akaike Information Criteria (AIC).

In table 4.6 ADCC models displayed minimum AIC in GJR/TARCH models in the case of KSE100, CSX, and the case of DSX. However, in the case of the BSX univariate GARCH model contains minimum AIC value.

According to results reported in Table 4.7, stability condition has been met because the aggregate of $\theta_{1,}$ and $\theta_{2,}$ is less than 1($\theta1+\theta2<1$) that shows that ADCC model is a good fit to measure time-varying dynamic conditional correlation as well as the asymmetric conditional correlation. In table 4.7 $\theta1$ is significant in case of BSX and CSX which shows that there exist the effect of past residual shocks on the current correlation of equity markets with crude oil, however, coefficients of $\theta_{1,}$ are insignificant in the context of KSE-100 and DSX which tells that there is no effect of past residual shocks on the current nexus among the crude oil and these equity markets. Parameter of $\theta_{2,}$ are significant in the context of BSX, CSX, and DSX which indicates that there exists lagged dynamic conditional correlation in equity

Table 4.7: Estimates of ADCC-GARCH Model

	θ_1	θ_2	θ_3
KSE100	0.016157	0.625555	-0.013399
	-0.1859	-0.2647	-0.439
BSX	0.008328	0.998459	0.005769
	0	0	0
CSX	-0.007798	0.035166	-0.022662
	0	0	-0.0156
DSX	0.0185	0.802713	-0.028775
	-0.2913	0	-0.4831

Note: This table contains the estimated coefficients obtained by using the ADCC -GARCH model for crude oil market and South Asian equity markets. p-values are mentioned in parenthesis. Theta (1), Theta (2) and theta (3) are reported above the p-values. The suitable univariate GARCH model is picked on the Akaike Information Criteria (AIC).

markets however, in the case of KSE 100 there is no lagged dynamic conditional correlation because the coefficient of $\theta_{2,}$ is insignificant. Asymmetric conditional correlation exhibited by $\theta_{3,}$ in table 4.7 indicates that asymmetric pattern exists in BSX as coefficient is significant and negative which means correlation is increased with coming of good news and coefficients are positive in case of CSX which tells that correlation is increased with coming of bad news. While other equity markets do not show significant asymmetric behavior that means that if good news or bad news arrives that does not affect the correlation of crude oil prices and equity markets prices differently.

After interpreting the tables of this section, it can be concluded that ADCC models are more accurate more reliable results have more authenticity as compared to the DCC model because it also captures the asymmetric patterns between series of different equity markets. So, it can be explained that the equity market has shown time-varying conditional correlation while also showed the asymmetric dynamic conditional correlation.

4.5 Cointegration Analysis of Crude Oil with South Asian Equity Markets

As it is mentioned in the methodological section short-term and the long-term relationship among series is observed by using cointegration analysis. For observing the short-term and long-term association, the VAR model has been constructed and the variance decomposition test is deployed to forecast the contribution of variation in the considered markets.

4.5.1 Unit Root Test

The unit root test is a preliminary statistical test to conduct a Co integration analysis. For conducting cointegration analysis it is assumed that series must be integrated at the same point. According to estimates of the Augmented Dickey-Fuller test reported in table 4.8 series of historical data are integrated at the same level (1st difference) so further cointegration analysis can be conducted to check short term nexus among the crude oil and South Asian equity market.

Table 4.8: Augmented Dickey-Fuller test (Unit Root Test)

Variable	Test Statistic	p-value
Crude oil	-2.648024	0.2588
Δ Crude oil	-79.70851	0.0001
KSE100	-1.551286	0.8118
Δ KSE100	38.71585	0
BSX	-2.445283	0.3558
Δ BSX	-75.08424	0.0001
CSX	-0.998879	0.9426
Δ CSX	-66.04145	0
DSX	-2.691255	0.2403
Δ DSX	-10.60217	0

Note: above stated table consists of the estimate of the Augmented Dickey-Fuller test along with T stats and their P-values respectively.

4.5.2 Vector Autoregressive Model (VAR)

When data meets the assumption of the stationarity and no unit root then the Vector autoregressive (VAR) model technique is an appropriate statistical model to measure the short-term link between the series. For the stationary purpose, indices are converted into the returns which are mentioned in section 4.1. Coefficients of VAR results with t values (in parenthesis) respectively are displayed in table 4.9 which reveals statistical results about the short-term association between Crude oil and KSE100, BSX, and CSX. According to statistical results reported in Table 4.9 future price behavior of crude oil can be forecasted by using past price shock because statistical results reported the significant coefficients at lag1,3 and 4 because their T stats are greater than 1.96. Meanwhile, in the context of KSE 100, BSX, and CSX it could be said that future prices can be forecasted from past price shocks because coefficients of these equity markets are significant at most of the lags. It also can be concluded that shocks created in the crude oil market dont create any effect in the South Asian equity market in the short-run because the T value of these coefficients is less than 1.96.

According to results reported in Table 4.10 past price shocks created in the Dhaka stock exchange can be used to forecast future price behavior because the T value of these parameters is higher than the margin level which is 1.96. It is also can be concluded that those shocks which are created in the crude oil market do not influence the return pattern of the Dhaka stock exchange because the coefficient that defines the nature of the short-term and long term relationship is insignificant their T values are less than 1.96 which is less than acceptable standard in research.

4.5.3 Variance Decomposition Analysis

Table 4.11 concludes the result which is obtained by applying the Cholesky decomposition of variance test. Statistical results reported in Table 4.11 include the results of the Crude oil market, KSE100, CSX, and BSX. This table analyses the variations in returns in percentage form which are contributed by factors of that market or maybe affected the returns patterns of other markets.

Table 4.9: Estimates of Vector Autoregressive Model (VAR)

	Crude oil	**KSE100**	**CSX**	**BSX**
Crude oil (-1)	-0.060644	0.023195	0.013125	0.006676
	[-4.49196]	[3.23971]	[2.38871]	[0.81735]
Crude oil (-2)	-0.010241	-0.005031	0.010462	0.008164
	[-0.75655]	[-0.70081]	[1.89908]	[0.99682]
Crude oil (-3)	0.035457	-0.003505	4.13E-05	0.002316
	[2.61962]	[-0.48833]	[0.00749]	[0.28283]
Crude oil (-4)	-0.031421	0.000139	0.001969	-0.013294
	[-2.32050]	[0.01940]	[0.35731]	[-1.62272]
Crude oil (-5)	0.005987	0.005934	0.006777	0.002942
	[0.44343]	[0.82870]	[1.23338]	[0.36008]
KSE100 (-1)	-0.014644	0.062774	-0.003527	0.002334
	[-0.57999]	[4.68835]	[-0.34321]	[0.15280]
KSE100 (-2)	0.024852	0.008601	-0.002165	-0.004637
	[0.98294]	[0.64147]	[-0.21042]	[-0.30315]
KSE100 (-3)	0.009773	0.072234	-0.011916	-0.026665
	[0.38781]	[5.40487]	[-1.16180]	[-1.74879]
KSE100 (-4)	-0.038475	0.011187	-0.025587	0.007125
	[-1.52208]	[0.83449]	[-2.48715]	[0.46587]
KSE100 (-5)	-0.018620	0.017485	0.012482	0.014296
	[-0.73867]	[1.30795]	[1.21669]	[0.93731]
CSX (-1)	0.132097	0.011479	0.126481	0.022168
	[4.03526]	[0.66121]	[9.49368]	[1.11925]
CSX (-2)	-0.019519	0.008789	-0.043532	0.001215
	[-0.59232]	[0.50292]	[-3.24598]	[0.06095]
CSX (-3)	-0.023440	-0.004254	0.006976	-0.025492
	[-0.71088]	[-0.24328]	[0.51985]	[-1.27778]
CSX (-4)	-0.015243	0.010755	0.013815	0.045631
	[-0.46285]	[0.61582]	[1.03072]	[2.29002]
CSX (-5)	0.047265	0.013149	0.055504	-0.005186
	[1.44959]	[0.76041]	[4.18268]	[-0.26289]
BSX (-1)	0.026958	0.022413	0.032697	0.000733
	[1.19982]	[1.88102]	[3.57569]	[0.05394]
BSX (-2)	0.007635	0.013718	0.018656	-0.021057
	[0.33962]	[1.15061]	[2.03899]	[-1.54805]
BSX (-3)	-0.013205	0.027128	0.019844	0.029929
	[-0.58741]	[2.27550]	[2.16892]	[2.20041]
BSX (-4)	0.014476	0.024020	0.013501	-0.023145
	[0.64344]	[2.01325]	[1.47447]	[-1.70031]
BSX (-5)	-0.047836	-0.007204	-0.016449	-0.001061
	[-2.12477]	[-0.60341]	[-1.79526]	[-0.07792]
Constant	8.71E-05	0.000255	0.000216	0.000331
	[0.34153]	[1.88480]	[2.07722]	[2.14203]

Note: Where KSE means the KSE-100 index, BSX denotes the Bombay stock market and CSX means Colombo stock exchange. Coefficients of the VAR model along with T-values in parenthesis are mentioned.

TABLE 4.10: Estimates of Vector Autoregressive Model (VAR)

	Crude oil	**DSX**
Crude oil (-1)	-0.023260	-0.007804
	[-1.12236]	[-0.26561]
Crude oil (-2)	-0.040787	-0.011362
	[-1.96758]	[-0.38662]
Crude oil (-3)	0.027503	-0.043522
	[1.32592]	[-1.48000]
Crude oil (-4)	-0.006195	-0.010877
	[-0.29869]	[-0.36990]
Crude oil (-5)	0.037672	-0.017905
	[1.81673]	[-0.60906]
DSX (-1)	0.016791	-0.488181
	[1.15258]	[-23.6376]
DSX (-2)	0.006103	-0.416291
	[0.38142]	[-18.3509]
DSX (-3)	0.017863	-0.279647
	[1.07481]	[-11.8689]
DSX (-4)	0.007215	-0.183702
	[0.45099]	[-8.09978]
DSX (-5)	0.004119	-0.088470
	[0.28274]	[-4.28320]
Constant	-0.000213	0.000245
	[-0.59949]	[0.48600]

Note: where DSX means Dhaka stock exchange. Coefficients of the VAR model along with T-values in parenthesis are mentioned.

According to results reported in Table 4.10 99% variation in the crude oil market is created by its own market-related factors. Variation in major South Asian equity markets is not affected by the crude oil market. In short-run 99% variation KSE returns are created by its own factors, the same case is in CSX and however, a 2% variation in Bombay stock exchange is caused by the variations in returns of crude oil markets but 95% of the variations are caused by the BSX related factors. 2% variations caused by the Crude oil market are a significant influence in returns of Bombay stock exchange.

Table 4.11: Estimates of Cholesky decomposition of variance test between crude oil market, KSE100, CSX and BSX

Variance Decomposition of Crude Oil					
Period	**S.E.**	**Crude oil**	**KSE100**	**CSX**	**BSX**
1	0.019064	100.0000	0.000000	0.000000	0.000000
2	0.019126	99.67477	0.002639	0.297223	0.025365
3	0.019128	99.65191	0.020587	0.298642	0.028856
4	0.019144	99.63053	0.022187	0.313542	0.033737
5	0.019161	99.57228	0.067574	0.314600	0.045546
Variance Decomposition of KSE 100					
1	0.010110	0.064417	99.93558	0.000000	0.000000
2	0.010147	0.309418	99.61776	0.010532	0.062287
3	0.010151	0.311959	99.56818	0.025329	0.094528
4	0.010186	0.310143	99.47056	0.025166	0.194131
5	0.010195	0.323275	99.35367	0.033732	0.289328
Variance Decomposition of CSX					
1	0.007758	0.025774	0.037942	99.93628	0.000000
2	0.007839	0.200182	0.037794	99.53988	0.222147
3	0.007849	0.308495	0.037798	99.32168	0.332026
4	0.007854	0.311913	0.054182	99.21092	0.422985
5	0.007862	0.318299	0.171808	99.03768	0.472217
Variance Decomposition of BSX					
1	0.011534	2.772609	0.916954	0.341500	95.96894
2	0.011536	2.784710	0.917202	0.363717	95.93437
3	0.011539	2.793243	0.920252	0.363987	95.92252
4	0.011549	2.793891	0.962990	0.386642	95.85648
5	0.011560	2.858978	0.962192	0.459758	95.71907

Note: estimates of this table present the outcomes of the variance decomposition test. All values are in percentage.

Table 4.11 provides the comparison of variations of returns among crude oil market and Dhaka Stock exchange

Table 4.12: Estimates of Cholesky Decomposition of Variance Test between Crude Oil and DSX

	Variance Decomposition of crude oil		
Period	S.E.	**Crude Oil**	**DSX**
1	0.017179	100.0000	0.000000
2	0.017189	99.94340	0.056596
3	0.017203	99.94226	0.057740
4	0.017212	99.91691	0.083086
5	0.017213	99.91602	0.083979
	Variance Decomposition of DSX		
1	0.024355	0.006273	99.99373
2	0.027102	0.005283	99.99472
3	0.027447	0.006281	99.99372
4	0.027455	0.057618	99.94238
5	0.027461	0.064208	99.93579

Note: this table presents estimates of variance decomposition test. All values are in percentage.

Statistical estimates reported in Table 4.12 indicate that there is no significant influence of crude oil on DSX. According to results, 99% of variations are caused by their own factors.

From the discussion in section 4.4, it can be concluded that in short term future prices behavior of crude oil markets and south Asian equity market can be forecasted by the past price shocks. In addition, it also can be concluded that variations in return of the crude oil market do not influence the variations in returns of South Asian equity markets. In short term variations in returns of South Asian equity markets may be caused by the country-specific variables or macro-economic variables. For example, exchange rate, GDP growth rate, and political instability, etc.

4.6 Dependence Structure between the Crude Oil Market and South Asian Equity Markets

As it is mentioned it the methodological section dependence patterns among crude oil market and South Asian equity markets are measured by employing Areathimedean copula (Clayton, Gumbel, and Frank) approach and elliptical (Gaussian and Student t copula) approach. Statistical results are mention below in different subsections. The best-fitted copula is selected by utilizing AIC criteria which are generally acceptable selection criteria in the research studies.

4.6.1 Dependence Structure among the Crude Oil Market and KSE 100

Table 4.13: Estimates of Dependence structure among the crude oil market and KSE 100

Copulae	**Initial Parameters**	**Final Parameters**	**Log Likelihood**	**AIC**	**Tail Dependence**	
					Lower	**Upper**
Gaussian	0.02289868	0.02061	1.155	0.3100723	0	0
t-Student	0.02289868	0.02415 / df=2.4017	230	-456.0309	0.1895529	0.1895529
Gumbel	1.014343	1.048	20.93	-39.8576	0.0000000	0.0624971
Clayton	0.02868505	.05305	7.78	-13.56064	1.42835e-05	0.0000000
Frank	-	0.1472	1.284	-0.5682542	0	0

Note: This table displays the estimates of Different copula parameters, log likelihood, Akaike information criterion (AIC) value and along with tail dependence structure between the crude oil market and KSE-100 index

According to statistical results reported in table 4.13 best-fitted copula for measuring the dependence of the crude oil market and KSE 100 is Student T copula which displays minimum AIC value (-456.0309). parameter of student t copula is positive and increased from .0228 to .0241. Statistical results suggest the symmetric response for tail dependence which means that upper tail and lower tail dependence are identical. It indicates that returns of the crude oil market and returns of Karachi stock exchange moves with the same frequency. The degree of freedom of T copula shows the fat tail dependence between the two-return series.

4.6.2 Dependence Structure among Crude Oil Market and BSX

The statistical result reported in Table 4.14 exhibits the parameter different copulas and their maximum log-likelihood, AIC values, and information about tail dependence which estimates the dependence patterns among the crude oil market and Bombay stock exchange returns.

Table 4.14: Estimates of Dependence Structure among Crude Oil Market and BSX

Copulae	**Initial Parameters**	**Final Parameters**	**Log Likelihood**	**AIC**	**Tail dependence**	
					Lower	**Upper**
Gaussian	0.1649881	0.1302	46.61	-91.22908	0	0
t-Student	0.1649881	0.1141 / df=1.8272	439.8	-875.6089	0.2360796	0.2360796
Gumbel	1.081159	1.116	91.52	-181.0471	0.0000000	0.1390267
Clayton	0.1623181	0.1977	86.96	-171.9159	0.0300150	0.0000000
Frank	-	0.8147	38.06	-74.12393	0	0

Note: This table consists on the estimates of Different copulas, loglikelihood, Akaike information criterion (AIC) value, and dependence structure among the crude oil market and BSX.

Table 4.14 noticeably suggests that Student t copula shows the minimum AIC value which matches the criteria of goodness of fit. Student t copula measures the fat tailedness in data. In this table, student t copula indicates the symmetric behavior of the crude oil market and Bombay stock exchange. The results also reveal that data is equally distributed among right and left tail. This means that there is a dependence structure between the sample market is identical. The crude oil market and Bombay stock exchange moves together in the same direction. The degree of freedom for t student distribution shows the fat tailedness between the two-return series. This implies that if the crude oil prices drop down it will decline the performance of returns of the Bombay equity market. Both markets move parallelly. Degree of freedom for t student distribution shows the fat tailedness between the two-return series

4.6.3 Dependence Structure among Crude Oil Market and CSX

Table 4.15 includes the parameters of different copula functions, their maximum log-likelihood, and their dependence structure estimates along with respective AIC value to estimate the dependence structure among the crude oil market and Colombo stock exchange returns. All copula functions show positive parameters with an increasing trend. However, this study is concerned with the best-fitted copula which shows minimum AIC value.

TABLE 4.15: Estimates of Dependence Structure among Crude Oil Market and CSX

Copulae	**Initial Parameters**	**Final Parameters**	**Log Likelihood**	**AIC**	**Tail dependence**	
					Lower	**Upper**
Gaussian	0.02410148	0.02833	2.168	-2.336445	0	0
t-Student	0.02410148	0.03724 / df=1.95995	329.7	-655.3129	0.197219	0.197219
Gumbel	1.017986	1.063	34.21	-66.41595	0.0000000	.08049573
Clayton	0.03597107	0.06213	10.25	-18.50544	1.428357e-05	0.0000000
Frank	-	0.2092	2.455	-2.909545	0	0

Note: This table shows the results of Different copula parameters, loglikelihood, Akaike information criterion (AIC) value, and tail dependency among the crude oil market and Colombo stock exchange.

According to statistical results reported in table 4.15 best-fitted copula to estimate the dependence structure among the crude oil market and Colombo, the equity market is student t copula. Student t copula is supposed to measure the fat tailedness of the dependence structure. In table 4.15 student t copula has minimum AIC value (-655.3129). It means that there is symmetric behavior is observed in the data. Both upper and tail dependence is similar because the data is equally distributed among both tails.

4.6.4 Dependence Structure among the Crude Oil Market and DSX

Table 4.16: Estimates of Dependence Structure among Crude Oil Market and DSX

Copulae	**Initial Parameters**	**Final Parameters**	**Log Likelihood**	**AIC**	**Tail Dependence**	
					Left tail	**Right tail**
Gaussian	-0.0172843	-0.03912	1.489	-0.9774173	0	0
t-Student	-0.0172843	-0.03936 / df=229.649	0.5433	2.913474	1.3581e-38	1.3581e-38
Gumbel	0.9758074	Assumption violated	Assumption violated	Assumption violated	Assumption violated	Assumption violated
Clayton	-0.0483851	-0.04839	4.400093	-6.800186	0	0
Frank	-	-0.214	1.311	-0.6224365	0	0

Note: This table consist of the Different copula parameters, log likelihood, Akaike information criterion (AIC) value, and tail dependency among the crude oil market and Dhaka stock exchange.

Table 4.16 includes the different copulas parameter functions, their maximum log-likelihood, and their dependence structure estimates along with respective AIC value to estimate the dependence structure among the crude oil market and the returns of Dhaka Stock Exchange. All copula parameters have followed the positive values with increasing patterns except Gumbel copula. Due to the negative value of Ro-tau (-0.02479236), final parameters are not calculated as a result of further calculation of dependence structure and the value of selection criteria is not calculated because of this negative value which violated the assumptions of Gumbel copula. However, this study is concerned with the best-fitted copula which shows minimum AIC value. According to statistical results reported in table 4.16 best-fitted copula to estimate the dependence structure between the crude oil market and Dhaka stock exchange is Clayton copula. Clayton copula is supposed to estimate the lower tailed-ness of the dependence structure. In table 4.16 Clayton copula has minimum AIC value (-6.800186). If the best fitted copula is Clayton copula then it means that there is a high frequency that crude oil market and South Asian equity markets are declining in the same direction at the same time regime.

From the above-mentioned discussion, it can be summarized that dependence patterns in crude oil market and KSE100, CSX and BSX is identical in nature which means that each south equity market adjusts in the same manner with crude oil market. If the prices of crude oil increases then incremental change in oil prices can be observed South Asian equity markets. However, Clayton copula is significant in case of Dhaka Stock exchange which means that there is lower tail dependence between crude oil market and Dhaka stock exchange. Which indicates that both market adjusts in same manners but follows the decreasing trend.

4.7 Spearmans Correlation and Kendals Tau

As it is mentioned in the methodological section the nexus of the crude oil market and South Asian market is also observed by spearman and Kendals Tau correlation techniques. That justifies the results of previous statistical techniques. Table 4.17 reveals the results of the correlation between crude oil and BSX, PSX, and CSX which states that correlation among these markets is significantly week which confirms the finding of previously mentioned statistical techniques.

Table 4.18 presents the correlation among crude oil and DSX in which it is indicated that the relationship among these markets is very week and direction is negative. These values confirm the finding of the previously mentioned statistical techniques.

So, from the results which are mentioned in this section, it can be said that crude oil does not influence the equity markets of the South Asian countries.

TABLE 4.17: Estimates of Spearmans Correlation and Kendals Tau Test

	Crude Oil	BSX	PSX	CSX
crude oil	1.000000	0.164988	0.022899	0.024101
BSX	0.164988	1.000000	0.098129	0.064620
PSX	0.022899	0.098129	1.000000	0.026030
CSX	0.024101	0.064620	0.026030	1.000000

TABLE 4.18: Estimates of Spearmans correlation and Kendals Tau Test

	CRUDE_OIL	DSX
CRUDE_OIL	1	-0.4718179
DSX	-0.471817	1

From the above discussion it can be summarized that the nexus among crude oil market and South Asian equity markets is weak which confirms the findings of Vector Autoregressive model and Copula approach. These finding also supports the results of variance decomposition test.

Chapter 5

Conclusion and Recommendations

5.1 Concluding Remarks

Crude oil is considered an integral part of an economy. Firms of an economy are bound to use crude oil as an input or output. Almost every sector of an economy is linked with crude oil. So, crude oil can interrupt the profit-generating capacity of the firm. If there is any shift in crude oil prices it will influence the different firms of an economy. Suppose if the crude oil prices follow the upward trend the equity market returns of an economy will decrease because the different costs may increase due to upward shift in crude oil prices. Aloui, Nguyen, and Njeh (2012) have argued that there is a negative linkage among the prices of the crude oil and equity market indices of emerging economies. This argument is also supported by Asteriou & Bashmakova (2013). Some authors showed a positive linkage like Wen, Bouri, and cheng (2019). But authors have not shown consensus in their findings. The impact of crude oil market returns on South Asian equity markets has not yet been fully addressed and no study is conducted until now to address the dependence structure. This study uses the copula approach which is the most appropriate technique to decompose the tail dependence between the variable. The importance of the copula approach has been discussed in detail in the methodological section of this study.

To address these gaps, this empirical study attempts to check the long and short-term among the crude oil market and South Asian equity markets. This study also addresses the time-varying association among the crude oil prices and South Asian Equity markets because usually, a correlation between financial assets does not remain the same over time. It may variate due to some macro-economic factors which may affect the crude oil market just like demand and supply shocks, financial crises, etc. Moreover, this study also plans to capture the dependence patterns among the crude oil market prices and equity market returns of South Asian countries. For achievements of its objectives, the study deploys the ARMA GARCH (1,1) and Vector Auto-Regressive (VAR) techniques to check the short term and long term and spillover effects of the crude oil market on South Asian equity markets. For checking the time-varying risk factor of the crude oil market, this study uses the DCC and ADCC GARCH models. The dependence structure among the crude oil market and South Asian equity markets are checked by using the copula approach.

Findings by using ARMA-GARCH models indicate that there is significant transmission of volatility from the crude oil market to considered South Asian equity markets however, returns spillover only exists in case of BSX. Vector auto-regressive methods have suggested that there is no significant short-term association between crude oil market and south Asian equity markets. This finding also confirmed by the variance decomposition technique. This suggests that most of the volatility contribution may be made by the macroeconomic factors of that equity market. Further, the findings of the study report the time-varying volatility between the oil and sample equity markets. ADDC models also suggest the asymmetric behavior between the equity markets examined.These findings are also supported by previous study which is carried out by Noor and Dutta (2017) in which it is summarized that there are evidences of significant transmission of volatility from oil market to South Asian equity market. So, findings of this study support the hypothesis no1 and 2. In the context of dependence structure, the findings provide that the Student T copula for Pakistan, India, And Srilanka shows that the tail dependence between the WTI index and these markets is identical. There is an equal distribution of returns on both tails however, the statistical results provided by the Clayton copula indicate as a significant dependence among crude oil market and Dhaka stock exchange. This means that there exists lower tail dependence among these two markets.

5.2 Recommendations

After concluding the findings of the study, this study provides recommendations to key players of the economies like investors, policymakers, portfolio managers, and risk managers of the firms to consider these aspects before making any decision. Some important recommendations are as follows:

- Crude oil prices behavior in the future should be considered before making investment decisions in South Asian equity stock. Existing stockholders should also be aware of the fluctuations linked with the oil market as these equity markets are somehow affected by crude oil prices.
- Policymakers should watch the expected influence and devise future strategies to manage risk in case of global transmission of information.
- Portfolio managers should consider the oil and equity nexus before making the portfolio diversification strategies. Because the South Asian equity market provides fewer opportunities for portfolio diversification. If the portfolio managers want to hedge in these markets should invest in those sectors which are less affected by oil prices.
- Before devising any risk management strategy, risk managers should also consider the oil- equity connection as it provides useful information for risk managers to avoid unsystematic risk.

5.3 Limitations and Future Directions

Although long-term relationships, short term relationships, the time-varying connection among the crude oil market, and the south Asian equity market have been studied deeply and have discussed the dependence patterns among crude oil market and south Asian equity markets. But it does not address the sector-wise link in these markets. So, more comprehensive research can be conducted to check the crude oil influence on a sectoral basis in these economies. Moreover, a comprehensive study can be conducted to check the extremely value movements between these markets based on conditional extremely value theory (C-EVT).

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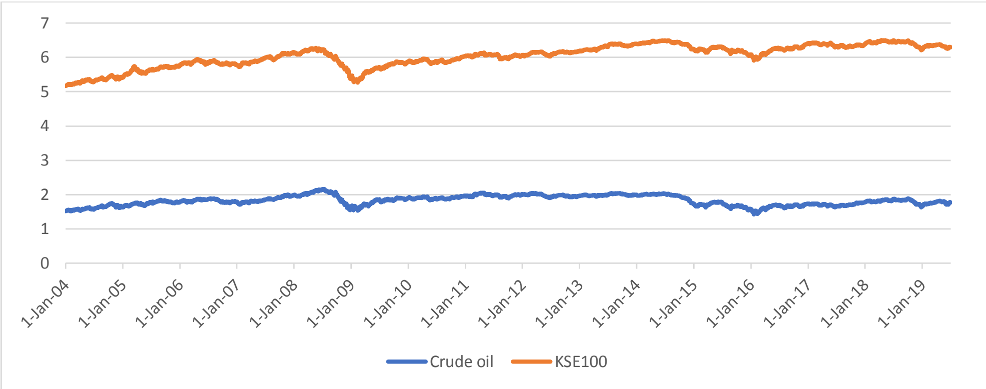
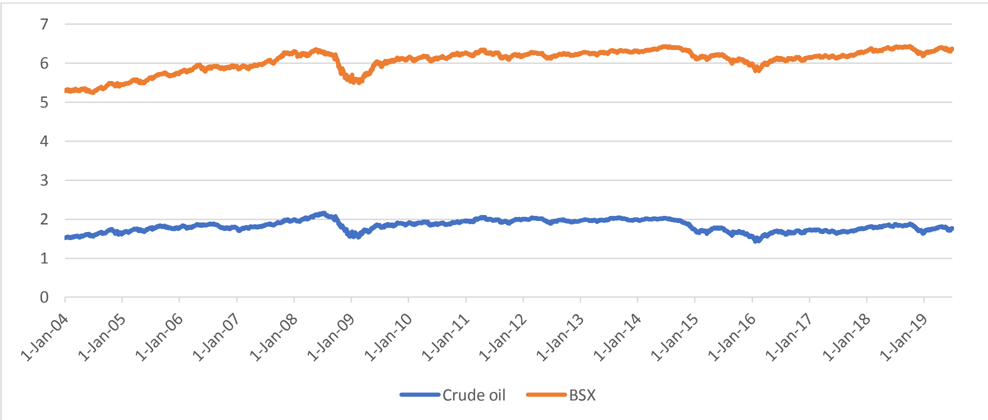
Appendix

Appendix-A

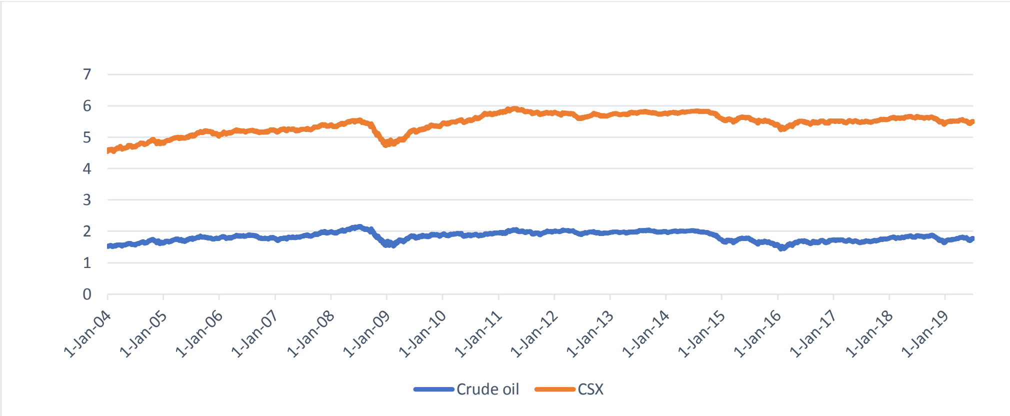
Stationarity Graphs



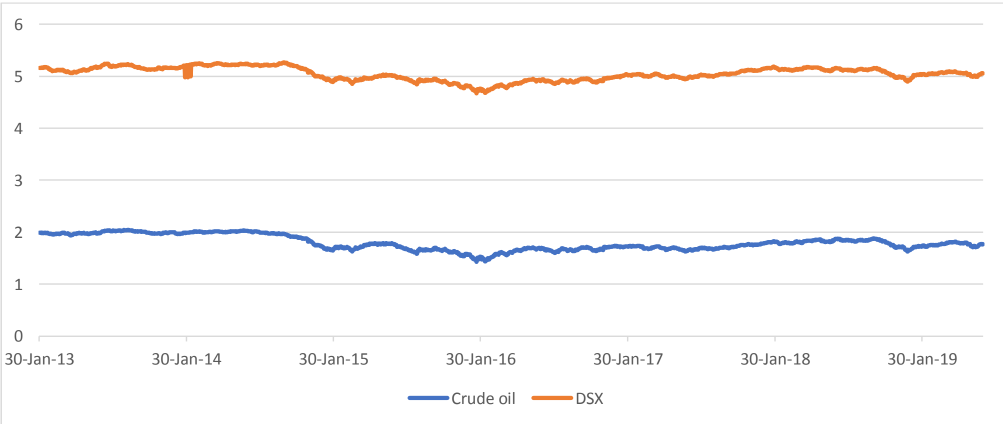
Crude oil Vs KSE-100



Crude Oil Vs BSX



Crude Oil Vs CSX



Crude Oil Vs DSX