Co-movement Analysis:

An Application of ARDL-GARCH Model

Submitted by

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CERTIFICATE

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List of Abbreviations

ARCH	Autoregressive Conditionally Heteroscedastic
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
ARDL	Autoregressive Distributed Lag
BEKK	Baba-Engle-Kraft-Kroner
VEC	Vector Error Correction
ACF	Auto Correlation Function
PACF	Partial Auto-Correlation Function
ARMA	Autoregressive Moving Average
KSE	Karachi Stock Exchange
PSX	Pakistan Stock Exchange
VARMA	Vector Autoregressive Moving Average
MGARCH	Multivariate Generalized Autoregressive Conditional Heteroskedasticity
GJR-GARCH	Glosten, Jagannathan and Runkle Generalized Autoregressive Conditional Heteroskedasticity

ABSTRACT

This study traces out the contemporaneous and time lag spillover effect by using ARDL-GARCH model and traces out mean and volatility spillover effects among the commodity, stock and forex markets. Particularly, it explores the contemporaneous and time lag volatility spillover effect, mean and lag mean spillovers among the exchange rate rupee against dollar, KSE 100 index, gold prices per tola in Pakistani rupee, and crude oil prices per barrel in Pakistani rupee. The daily data are used from 3rd Jan 2007 to 29th Nov 2019.The ARDL-GARCH model is used to estimate contemporaneous and time lag spillovers effect and the symmetric GARCH model are used for volatility modeling.

The results conclude that the return series of KSE 100, Crude Oil prices has asymmetric effect and Exchange Rate, Gold Prices having symmetric effect.

The results of contemporaneous and lag mean spillover effect indicate that there is contemporaneous, and lag means spillover effect between KSE 100 and gold prices. There is lag mean spillover effect from KSE100 to exchange rate, from crude oil to KSE100. There is bidirectional mean spillover effect between crude oil and gold prices, exchange rate and gold prices. There is no mean effect between exchange rate and gold prices, between crude oil and exchange rate, there is no mean spillover effect from exchange rate to KSE 100, from KSE100 to crude oil. There is no lag mean spillover effect between gold prices and KSE100, between crude oil and exchange rate, between crude oil and gold prices, there is no lag mean spillover effect from exchange rate to KSE100, from KSE100 to crude oil prices, from gold to exchange.

The results of contemporaneous and lag volatility spillover effect indicate that there is contemporaneous and lag volatility spillover effect between KSE 100 and exchange rate, between crude oil and exchange rate between exchange rate and gold prices ,there is contemporaneous and

lag volatility spillover effect from KSE 100 to crude oil prices ,from gold prices to crude oil prices. There is no lag volatility spillover effect between gold prices and KSE100, there is no lag volatility spillover effect from crude oil prices to KSE100, from crude oil prices to gold prices.

Key words: *Spillover effect, Volatility, GARCH, GJR, ARDL-GARCH.*

CHAPTER 1

INTRODUCTION

The globalization is the major cause of information transmission amongst the markets. This globalization is based on easy flow of capital, sharp technological growth, and links amongst the markets. All these factors cause of spillover amongst the markets and with growing associations among the markets it is necessary for academicians, researchers, and market players to analyze the nature of these spillovers for macroeconomic and financial stability.

The associations between the currency and stock market is one of the major issues within a country for policy makers and international and domestic investors who are managing risk in their portfolios. There are two types of theoretical models which explain the relationship between the currency market and stock market, first is known as flow oriented or international trading model and second is known as stock oriented or portfolio balance model. The flow-oriented theory offered by Dornbusch and Fischer (1980) and argued that the currency market and stock prices are having positive relationship. It is also called international trading model because they suggest that exchange rate rely upon the current account balance or trade balance.

They also explained that competitiveness on international level and the trade balances might be impacted by varying exchange rate. That is why it has influence on inputs and country's real income. This phenomenon can be explained as domestic currency devaluation makes local firms competitive by providing less expensive exports in international market. The up rise in exports leads to increase the assets of domestic firms which further leads to appreciate the local stock market prices of national firms (Tachibana, 2018). There are few studies which explored linkages between these markets. There is a contemporaneous and long run causal relationship between these markets in case of Pakistan (Aslam, 2014; Bhutt et al., 2014; Suriani et al., 2015; Abbas et al., 2017").

The second model is stock oriented which is presented by Frankle (1983) which was further modified by Branson and Henderson (1985) explained that the equity, bounds, and financial assets are the determinants of exchange rate in any economy. This model divided into two more model's portfolio and monetary models. The monetary model consider that the stock market and the exchange rate has minor or weak relationship. According to this model exchange is a price of asset and future expected prices determined it. Similarly, the exchange rate is determined through future foreign exchange rate. Any variation in the determinants of exchange rate future expected prices will impact current exchange rate value. If the determinants of the both series are same then we it is quite possible there is positive association in the series (O'Donnell & Morales, 2009).

The portfolio model indicates that there is negative relationship between the exchange rate and the stock market prices. It also explains that there is unidirectional causal relationship between stock prices and exchange rate form stock prices to exchange rate. According to this model when stock prices increases the investor try to get more and more domestic assets which urge the investor to sell out the international assets in order to get more domestic assets. Consequently, it leads to grow in the wealth of the investor because of increase in domestic stock prices. This process further motivates the investor to increase his domestic assets which will increase the in-interest rate, at the end in this way domestic currency got appreciation (Adjasi et al., 2008).

From last few decades; the world economy has been experienced with an extraordinary boom in commodity prices with huge fluctuation. Investor always wanted to have a greater exposure to the commodity prices, through directly acquiring commodities by captivating absolute position in the commodity futures (Iscan, 2015). The commodity prices cycle's dynamics are ongoing consideration of market partakers and policy makers because the dynamics trigged volatilities in financial and economic development (Sedik & Cevik, 2011).

There is evidence that the stock and commodity markets are having linkages and these linkages got more strengthen from early 21st century (Olson et al., 2014). The commodity market prices (oil prices) and the stock markets prices are having bidirectional causal linkages, and both significantly impacted each other. There is also volatility spillover effect between them (Chaibi & Ulici, 2014). The oil prices, gold prices, stock markets prices, exchange rate are interlinked and any variation in equity market prices produce volatility in oil, gold prices and exchange rate (Ahmad et al., 2017).

There are some empirical studies explore the association between stock market, commodity market prices and exchange rate. To investigate of relationship between stock market prices, commodity market and exchange rate following studies have been done. There is long run relationship between exchange rate and stock market prices in Asian countries but in case of Pakistan there is no evidence of such relation has been found (Muhammad & Rasheed, 2002). There is no significant clue that there is causal relationship between stock market prices and exchange rate in case of Pakistani and Bangladesh (Smyth a& Nandha, 2003). The exchange rate, interest rate and stock market prices are positively associated with each other (Ahmad et al., 2010). The volatilities of exchange rate and stock market prices are having bidirectional causal linkages (Aslam, 2014). The treasury bills, M2, exchange rate and stock market prices associated with each other in short run and long run periods (Abbas et al., 2017).

The major commodity market prices like cotton, gold and sugar prices risk and returns are correlated with risk and return of stock market prices and there is seasonal asymmetric effect has been existed (Hunjra et al., 2011). There are strong causal linkages from stock market to oil and gold prices in case of 14 Asian countries including Pakistan (Thuraisamy et al., 2012). The prices of share market are significantly interlinked with common commodity prices; metal, crude oil, agriculture, food and beverages, fuel and non-fuel and stock market prices. The food

and beverages, metal and oil prices are positively impacted the stock prices, and fuel and non-fuel, agriculture, crude oil prices are having negative correlation with stock prices (Haq et al., 2017).

All these studies have done work to check the contemporaneous linkages among the series, but literature also indicates about time lag spillover effect. We are unable to find out any studies which explore time lag effects. But these empirical and theoretical studies show that there are linkages among these series. So, there is dare need to explore these time lag spillover effects.

1.1 Research Gap

All these previous theoretical and empirical studies which have been done before indicating that there are linkages between stock market prices, forex and commodity prices. It is observed that the existing studies used either univariate techniques by following Hamao et al. (1992) or multivariate modelling by employing GARCH modeling. All the previous studies estimate the instantaneous spillover effect, but it is observed there is time lag spillover effect. So, to estimate this effect we will use ARDL-GARCH model which is important addition in simple GARCH model to estimate the spillover effect among these markets. The ARDL-GARCH is used to check the contemporaneous as well as time lag spillover effect of one market on other market. Ghouse and Khan (2017) explored the spillover effect between domestic and international stock markets.

In this study they did not incorporate the commodity and forex markets. Also, they did not check the impact of lag spillover effect spillover effect the only explored contemporaneous spillover effects. In this way this study is significantly differ from their study. The ARDL-GARCH model allows us to introduce the lag value of return and volatility series of other market in the conditional mean and conditional variance equations. While ARMA- GARCH is

a univariate process it does not allow us to introduce the lag values of other series. It shows that ARDL-GARCH is a generalized form of ARMA-GARCH model.

We are also unable to find any study which explore the return and instability spillover effects among commodity, stock and forex market in case of Pakistan. The previous studies also contradicting regarding relationships among equity market and exchange rate. This study in this setup contributes in literature, first to check is there any contemporaneous as well as time lag spillover effect of one market to other market through ARDL-GARCH model. Second to explore the return and the volatility co-movements among commodity, forex and equity markets.

1.2 Research question

Whether the information transmit simultaneously or with lag time period?

1.3 Objectives of the Study

1. To examine whether there any contemporaneous as well as time lag spillover effect of one
   market to other market through ARDL-GARCH model.
2. To explore the return and the volatility co-movements among commodity, forex and equity markets.

1.4 Significance of Study

The huge amount of theoretical and empirical literature show that the equity, forex and commodity prices are having significant linkages. But we are unable to find out any study in Pakistan, so there is dare need to explore the spillover effect between these markets. This study is also important in its nature because we use and extensive model of GARCH type family which is not used before for this purpose. The ARDL-GARCH model ran to estimate spillover effects among these markets. All the previous studies only find out contemporaneous spillover

effect, but we estimate contemporaneous and as well as time lag spillover effect through ARDL-GARCH model. This study helps policy makers and financial market players to make sustainable macroeconomic and financial policies.

1.5 Scheme of Study

Chapter one presents the introduction of study, objectives of study, research gap, research question and significance of study. Rest of the research is arranged as follows, the next chapter reviews literature this chapter contain two parts in first part of literature review we Explore Causal Linkages between Stock Exchange and Forex Markets and in the second part of literature. We Explore Causal Linkages in the Presence of ARCH Effect between Equity and Commodity markets.

In Chapter 3 we have methodology and model specification here we discuss about ARCH, GARCH,GJR GARCH model, and ARDL GARCH model, MGARCH which is the extensions of the univariate GARCH model and VEC and BEKK Models .After that we explain about the data and variables which are used in our study and graphical representation of data series, we explore the basic characteristics of raw data series about their trends, normality and fluctuation. And in return series we discuss about volatility clustering and ARCH effect. Then for data generating process of the series and model specifications we employ the autocorrelation function (ACF) and partial autocorrelation function (PACF). For distribution analysis we plot the distribution of the return series.

Chapter 4 explores heat wave spillover effect among commodity, forex and stock market prices. In commodity markets we will take daily data on crude oil prices per barrel in term of Pakistani rupee and gold prices per tola in Pakistani rupee In case of forex market, we will take daily data on Exchange rate of Pakistani rupees against USA dollar while for stock prices we will collect daily data on KSE 100 index of PSX. This chapter contains the outputs

of return and volatility co-movements effect particularly, the contemporaneous and lag volatility spillover which are attained by employing the GARCH and ARDL GARCH models. The first section of chapter based the volatility modeling of the return series of KSE100 Gold prices Exchange rate and Crude oil. The second section based on contemporaneous mean spillover effect and time lag mean spillover effect which is measured by using conditional mean equation. The third section of this chapter is about the contemporaneous volatility spillover effect and time lag volatility spillover effect which is measured by using conditional variance equation. While in Chapter 5 we conclude all the results given in chapter 4 and suggests some policy implications.

CHAPTER 2

REVIEW OF LITERATURE

This section based on the reviews of those studies which have been done to explore the linkages among equity, forex and commodity markets, especially in case of Pakistan. Many researchers presented their theoretical and empirical model on these spillovers. In this section we review previous studies on this topic. The arrangement of the section is following:

2.1 Exploring Causal Linkages between Stock Exchange and Forex Markets

There is rising empirical literature on causal relationship between stock exchange and exchange rate. Muhammad and Rasheed (2002) take the case of south Asian countries and explore cointegration between stock market prices and exchange market .They used Johansen cointegration test to explore the long run relations and found that there was no confirmation of long run and short run relationships in case of India and Pakistan. While in case of other countries they found mixed results. Smyth and Nandha (2003) explains the causal linkages between stock market prices and foreign exchange rate in case of South Asian countries; Pakistan, Bangladesh, Sri Lanka, and India. They used Granger causality and Johansen cointegration procedures for empirical relations. They found that there was no clue of causal relation in case of Pakistan and Bangladesh.

Farooq et al. (2004) examine the causal linkages between exchange rate and stock market returns. They used Johanson cointegration test to find long run relationship and Granger causality procedure to check the causal relationship between both series. The results indicated that there was a causal relationship between the exchange rate and stock market general index. They explored that the causality runs towards index of services sector from exchange rate.

Qayyum and Kemal (2006) explored the dynamic relationship between foreign exchange with stock market. They used Engle Granger cointegration for long run relationship and EGARCH

model for uncertainty co-movements. They find that there was a bidirectional volatility spillover effect between foreign exchange and stock market in case of Pakistan. And there don't exist long run relationship exists between the two markets.

Rahman and Uddin (2009) estimated the empirical relationships between foreign exchange rates and stock market prices in case of selected South Asian countries. The Granger causality test had been used for causal linkages and Johansen cointegration employed to check short run and long run relationships and found that there were no causal linkages and cointegration among the series in case of all countries. Sohail and Hussain (2009) examined the short run and long run relationships between Lahore stock market prices and foreign exchange rate. They used Johansen and Juselius procedure. They found that there was a positive relationship between stock prices and exchange rate.

Ali et al. (2010) explored the relationship amongst the main macroeconomic indicators of Pakistani economy; balances of trade, industrial production, exchange rate, inflation and stock market prices. They used Granger causality and Johansen cointegration procedures for relationships. They found no causal linkages and among stock prices and macro indicators in case of Pakistan. Ahmad et al. (2010) found the relationship amongst interest rate, foreign exchange rate and stock market prices in case of Pakistan. And used multivariate regression model to check the degree of relation between the variables. They found that the interest rate and foreign exchange rate shows positive link between prices of the stock market.

Zia and Rehman (2011) studied about the causal relationship between foreign exchange and the stock market. They used Engle Granger cointegration test, Granger causality to explore the relationships and found no causal relationship between the series .Jawaid and Haq (2012) inspected the relationship among volatilities of interest and exchange rate and banking sector prices of equity market. They employed GARCH, Granger causality, and Johansen cointegration to find out the linkages amongst them.They found significant relationship

amongst interest rate, exchange rate and stock prices and explored the unidirectional causality direction from interest rate to stock market index.

Aslam (2014) examined the relationship between volatility of stock market and volatility of forex market. “They found level stationary series and employed Granger causality to examine the direction of causality among spread series of both markets. They also concluded that there was a bidirectional causal relationship between both markets. Bhutt et al. (2014) inspected the relationship among exchange rate and seven macroeconomic variables: stock prices, exports, industrial products, inflation, money supply, total reserves less gold, and balance of trade. They used Johansen cointegration test and Granger causality test to find out long run and causal relationships among variables. They concluded there is no sign of cointegration and causal relationships between exchange rate and stock prices.

Suriani et al. (2015) explored the volatility spillover between Pakistan exchange market and stock market. They used monthly data from 2004 to 2009 and employed Granger causality test to identify the causal directions of the relationships. They found that there was no evidence of causal relation among the both series. Abbas et al. (2017) studied the cointegration and causality among M2, treasury bills of 180 days, currency rate and equity prices. The monthly data were used from 2000 to 2015. The results revealed that there was cointegration among the variables of three markets. They also employed VAR and Granger causality procedures to test causal relations and found storing short run and long run causal relation among the variables of money, forex and stock markets.

Almost all the studies indicate that there is causal short run and long run relationship between forex and equity markets in case of Pakistan except (Muhammad & Rasheed, 2002; smyth & Nandha, 2003; Rehman et al., 2009; Ali et al., 2010). Some researcher also explored there only short run relationship between the series but there is no long run relationship (Zia & Rehman, 2011; Bhutt et al., 2015). The results of these studies are contradicting with each other

that is why there is dare need to re-estimate these relationships to solve this paradox with fully updated data set.

2.2 Exploring Causal Linkages in the Presence of ARCH Effect between Equity and Commodity Markets.

There are many experimental studies in Pakistan which show that there are significant causal linkages between commodity and equity markets. Hunjra et al. (2011) inspected the relationship amongst risk and return of stock market prices and major commodity market prices; gold, cotton and sugar prices. The monthly data had been used from 1998 to 2008 and employed GARCH model to estimate the linkages. They found asymmetric seasonal effect in all the series, but the stock prices had more as compared to others. Khan (2012) explored the correlation between Pakistan mercantile exchange commodity index and KSE 100. The daily data had been used for analysis from 2009 to 2012. They employed correlation matrix and found that there was a strong correlation between both indices.

Thuraisamy et al. (2012) traced the spillover effect between 14 Asian countries stock market prices and oil and gold prices. They used monthly data 2005 to 2011. The GARCH BEKK model is also employed for spillover detection. The results illustrated that in mature stock markets the direction of spillover was to oil and gold future prices, while in immature stock markets direction of volatility spillover was from the commodity market indices to the stock market index. The results also indicated that there was a bidirectional volatility spillover effect among the indices. Shahzad et al. (2014) modelled the returns and volatilities of commodities and stock market series. The returns and risk of stock and commodity markets were having asymmetric distribution. The GJR-GARCH model had been used to model the stock and commodity market series. The results indicated that the future commodity prices significantly impacted by inflation rate and inverted asymmetric nature had been found in commodities returns. They concluded that investment in commodities provided inflation

protection and diversifications.Chaibi (2014) studied the volatility spillover effect between the stock market indices of 21 worldly stock markets and oil prices. The data had been used form the period of 2008 to 2013. They employed GARCH BEKK model and Granger causality test. The results indicated that there was significant spillover effect among the both indices.

Shaique et al. (2016) examined the associations between stock market prices and gold prices in case of Karachi stock market. Monthly data is used from 1993 to 2014 they use vector autoregressive and Johnson cointegration techniques and found that there was no long run relationship between the series. They also found that the current month gold prices heavily depend on the previous month prices.

Ahmed et al. (2017) studied the linkages among oil prices, exchange rate, gold prices, and equity prices for Pakistan economy and used monthly data from 2005 to 2015 the estimation technique they use are vector autoregressive model and impulse response function and found that the variation in stock prices also produce variations in oil, gold prices and exchange rate. And see that there is negative and significance association between exchange rate and stock market. Haq et al. (2017) take data on crude oil, metal, food and beverages, agriculture, fuel, non-fuel and equity market prices in the case of Pakistan. The data is taken annually from 1995 to 2016 and used ARDL cointegration. The results were indicated that the food and beverages, metal and oil prices had significant and positive impact on KSE 100 while other remaining variables have negative but significant relationship. The short run results indicated that except non-fuel and fuel prices have significant and positive impact on KSE 100.

Ahmad et al. (2018) inspected the long run and short run association among the stock market returns and gold and oil prices in case of South Asia and Baltic stock markets. They used monthly data from 2010 to 2016 and employed Johansen cointegration test and Granger causality test for long run, short run and causal relationships. They found there was no long run and causal relationship between commodity and stock market indices. After reviewing above

studies, we come up some findings; there is a strong linkage among foreign exchange market, major indices of commodity market and stock market index. We are unable to find any study which explore time lag spillover effect by using ARDL-GARCH models and the return and volatility spillover effect among three market indices.

CHAPTER 3

METHODOLOGY AND MODEL SPECIFICATION

The volatility modeling is the biggest issues in economics and especially in financial econometrics literature. The elementary purpose of financial econometrics is to calculate the time variant volatility. The financial econometric modeling is employed to quantify historic nature of time series, forecasting of the volatility, leverage effects, volatility clustering and shock's persistence. The GARCH type models are also employed to estimate the spillover effects between the financial series. The term spillover is also known as co-movement or information transmission. In this study we will use an extensive GARCH model which is ARDL-GARCH model. It can estimate the both contemporaneous as well as time lag spillover effect.

3.1 Model Specification

The financial data series are commonly nonstationary and trendy in nature. The trendy series does not provide valid results that is why we must make them stationary or de-trended. For this purpose, we use log difference of series.

$$\mathrm{R_t} = \log\left(\frac{k_t}{k_{t-1}}\right) \qquad (3.1)$$

k_t= Series at level i.e. exchange rates and stock indices at current time.

k_{t-1}= First lag of raw series.

3.1.1. Autoregressive Conditional Heteroskedastic (ARCH) Model

The modeling of time varying volatility is not an easy task for financial analysists since late 20th century. To tackle this problem Engle (1982) introduced ARCH model. The ARCH model simultaneously deals with two equation at same time; first is the mean equation and

second is volatility equation. The conditional mean equation estimates the data generating process of series or return series while the conditional volatility equation is quantifying the process of data generation of variance. The first equation based on ARMA (p, q) process of financial time series and second equation consists on the lag term of squared residuals of first equation which is also known as ARCH term.

The generalized equations of ARCH model are following:

Conditional Mean Equation

$$R_t = \omega_0 + \omega_1 X_t + \varepsilon_t \quad (3.2)$$

Where $\varepsilon_t = z_t \sigma_t, \quad z_t \sim N(0,1)$

Conditional Variance Equation

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \theta_i \, \varepsilon_{t-1}^2 + u_t \quad (3.3)$$

where i= 1, 2, ……., p

The R_t indicates the return series and ω_1 show parameters vector of ARMA process. It can be ARMA (0, 0) process in specific cases. There are two main restrictions imposed on ARCH model in literature are it deals with symmetric effects but not with asymmetric effects and parameters of the conditional variance equation must not be negative and return series is presented as linear function of explanatory variable Xt, The ε_t shows the error term and $\varepsilon_{t-1}^2$is included as ARCH term.

3.1.2. Generalized Autoregressive Conditional Heteroskedastic (GARCH) Model

The GARCH model is a general extension of the ARCH model. The ARCH model is sometime facing long length problem of the ARCH term. This problem creates ultimately reduce the degree of freedom. To overcome this problem Bollerslev (1986) introduced GARCH model. Ghouse and Khan (2017) employed GARCH model to quantify the spillover effect between stock market prices. Javed et al. (2014) employed GARCH model to model the

inflation and uncertainty in inflation. The extension in GARCH model is generalized form of ARCH model because it includes the lag value of the conditional variance as explanatory variable in the conditional variance equation.

The GARCH (p, q) equations are following:

Mean Equation

$$R_t = \omega_0 + \omega_1 X_t + \varepsilon_t \quad (3.4)$$

Whereas $\varepsilon_t = z_t \sigma_t, \quad z_t \sim N(0,1)$

Variance Equation

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \theta_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \delta_j \, \sigma_{t-j}^2 + u_t \quad (3.5)$$

The R_t indicates the return series and ω_1 show parameters vector of ARMA process. It can be ARMA (0, 0) process in specific cases. There are two main restrictions imposed on ARCH model in literature are it deals with symmetric effects but not with asymmetric effects and parameters of the conditional variance equation must not be negative. Here the return series is presented as linear function of explanatory variable Xt, The ε_t shows the error term and $\varepsilon_{t-1}^2$is included as ARCH term. The σ_{t-i}^2 is lag value of the conditional variance is used as explanatory variable.

3.1.3 GJR-GARCH Model

The ARCH and GARCH models only deal with symmetry. They do not consider asymmetric information for this Glosten et al. (1993) proposed model which check the effect of special event in ARCH term.

The GARCH (p, q) equations are following:

Mean Equation

$$R_t = \omega_0 + \omega_1 X_t + \varepsilon_t \quad (3.6)$$

Whereas $\varepsilon_t = z_t \sigma_t, \quad z_t \sim N(0,1)$

Variance Equation

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \theta_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \delta_j \, \sigma_{t-j}^2 + \sum_{i=1}^{r} \psi_i D_i \, \varepsilon_{t-i}^2 + u_t \quad (3.7)$$

There is only addition of dummy variable which is interactive with ARCH term and capture the effect of any asymmetric information effect in ARCH term. GJR-GARCH capture possible asymmetric impact of positive and negative shocks on conditional variance equation.GJR-GARCH encompasses the GARCH model while EGARCH doesn't, that's why we use it. If the null hypothesis of asymmetric effect is rejected we can easily move to restricted model GARCH.

3.1.4 ARDL-GARCH Model

The ARDL-GARCH is a more generalized form of GARCH model which can be used to check the contemporaneous and as well as time lag spillover effect. This model is never used before we are using this model first time in our study after extending the simple GARCH.

The ARDL-GARCH equations are following:

Mean Equation

$$R_t = \omega_0 + \sum_{i=1}^{p} \theta_i \, R_{t-i} + \sum_{i=1}^{q} \delta_i \, \varepsilon_{t-i} + \sum_{i=0}^{r} \gamma_i \, X_{t-i} + \varepsilon_t \quad (3.8)$$

Whereas $\varepsilon_t = z_t \sigma_t, \quad z_t \sim N(0,1)$

Variance Equation

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^{p} \theta_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \delta_j \, \sigma_{t-j}^2 + \sum_{i=0}^{r} \theta_i \, K^2{}_{t-i} + u_t \quad (3.9)$$

In conditional mean equation The term R_t indicates the return series and ω_0 shows intercept θ_i shows impact of lag return on return series and δ_i shows moving average process and its shows impact of lag of residual on return series γ_i shows current value and contemporaneous lag effect and the term ε_t shows the error term.In conditional variance equation The term σ_t^2 indicates the

volatility series ε_{t-1}^2 is included as ARCH term. The σ_{t-j}^2 is lag value of the conditional variance is used as explanatory variable. The term $K^2{}_{t-i}$ is the vector of current and lag squared values of other return series.For mean spillover effect and lag mean spillover effect we will include current and lag values of return of other series in mean equation and for volatility spillover effect we will introduce current and lag values of square return of other series in the conditional variance equation. If the current and lag values in both equations will be found significant it will show that there is current, and lag mean and volatility spillover effect.

3.1.5 Multivariate GARCH Methodology:

The models in this category are multivariate extensions of the univariate GARCH model. When we consider VARMA models for the conditional mean of several time series the number of parameters increases rapidly. The same happens for multivariate GARCH models as straightforward extensions of the univariate GARCH model. Furthermore, since H_t is a variance matrix, positive definiteness must be ensured.

VEC and BEKK Models

A general formulation of H_t has been proposed by Bollerslev et al. (1988).

The VEC (1,1) model written as

$H_t = c + A \propto_{t-1} + Gh_{t-1}$ (3.10)

Where,

H_t= VECH (H_t)

$\propto_t = vech(\varepsilon_t \varepsilon'_t)$

In the general VEC model, each element of H_t is a linear function of the lagged squared errors and cross-products of errors and lagged values of the elements of H_t

3.2 Data and Description

The data set are based on commodity, forex and stock market daily close prices. In commodity markets we will take daily data on crude oil prices (Petroleum) per barrel in term of Pakistani rupee. and gold prices per tola in Pakistani rupee. In case of forex market, we will take daily data on Exchange rate of Pakistani rupees against USA dollar while for stock prices we will collect daily data on KSE 100 index of PSX. The daily data are used from 3rd, jan,2007 to 29th Nov 2019.The main sources of data are Pakistan stock market, Yahoo finance and Business Recorder.

3.3 Data Visualization

This section is about the graphical representation of data series. The data visualization is also known as data exploratory data analysis. In this section we explore the basic characteristics of data series first the raw data series about their trends, normality and fluctuation. After that, the return series and discuss about the volatility clustering and ARCH effect. Then for data generating process of the series and model specifications we employ the autocorrelation function (ACF) and partial autocorrelation function (PACF). For distribution analysis we plot the distribution of the return series.

3.3.1 The Raw Series

Figure 3.1 - The Raw Data Series from 2007 to 2019

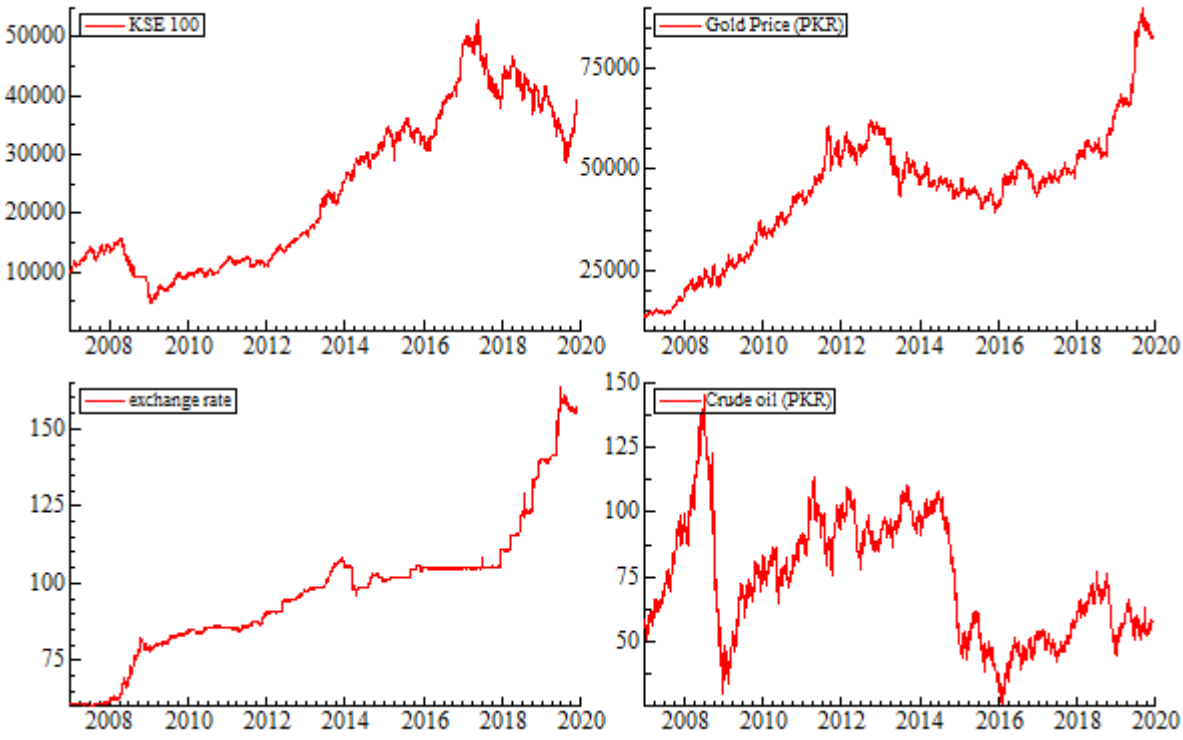
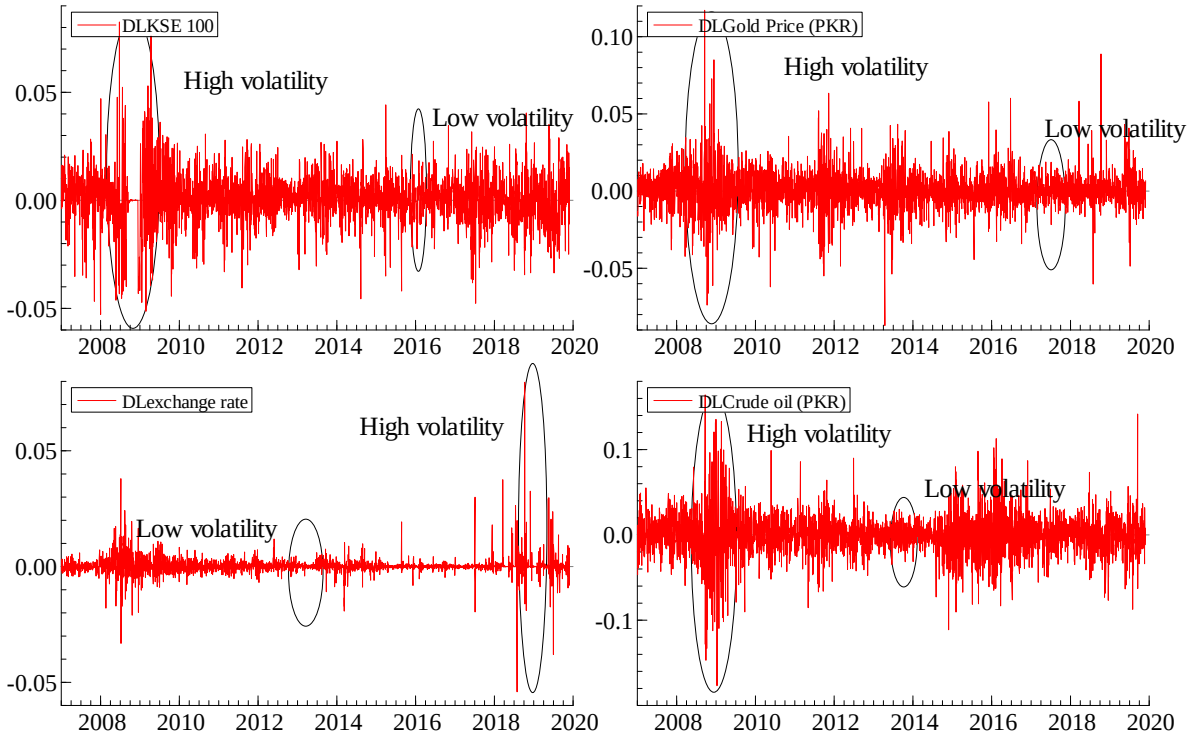


Figure 3.1 shows the return series of KSE 100 index, Exchange rate of Pakistani rupees against USA dollar (Exchange rate), gold prices per tola in Pakistani rupee (Gold Price), and crude oil price per barrel in term of Pakistani rupee (Crude Oil Price).The graph of all the series are showing that the series are upward trending with some minor and some heavy fluctuations. The KSE 100 and crude oil price series are having huge fluctuation due to 2008 financial global crisis.

While the second huge decline in oil prices is due to reduction in oil prices in international market. But the overall trend shows that all the series are having stochastic upward trend. It shows that the series are trend and nonstationary. That is why the GARCH type can never be employed on nonstationary series because the results by getting through nonstationary

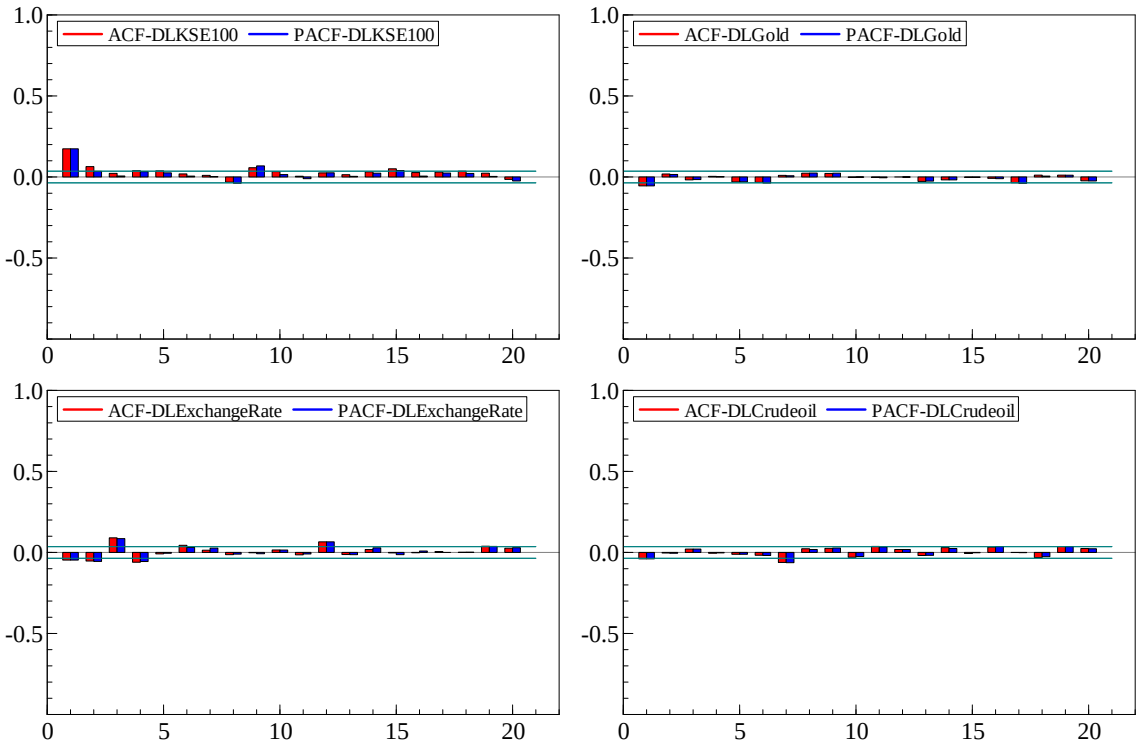
series are invalid and misleading. To make results valid and useful we take the log difference of all the raw series and make return series.

Figure 3.2 - The Return series from 2007 to 2019



In all the panels of figure 3.2 the long dash lines shows the high volatility clustering and the solid lines show the low volatility clustering. It also shows that the high departure for mean value generates again high spread and produces a group, that bunch of huge volatility makes high volatility cluster. Similarly, the low variance generates again low spread and makes gathering of low volatility that is called low volatility clustering. So, this type of low and high volatility clustering indicating about the existence of ARCH effect in the return series and we can apply GARCH type modeling. Also, the series are now detrended and moving around mean value which shows that the series are now stationary. Now for model specifications we employed ACF and PACF.

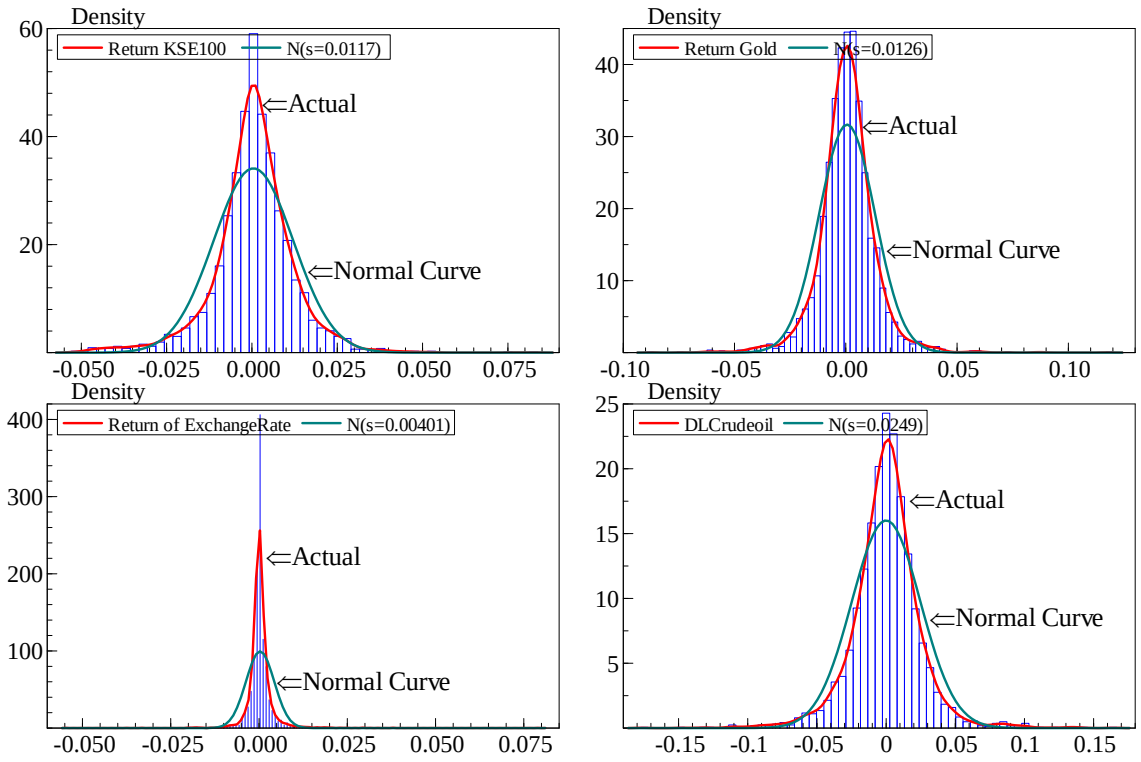
Figure3.1 - ACF and the PACF of the Return Series



The figure 3.3 shows the autocorrelation and partial autocorrelation functions of return series, which is also used for the specification of autoregressive moving average process (ARMA). In all the panels the red bars show the ACF and blue bars show the PACF. The bars which are outline the green line bend show that lag is significant and highest lag is the order of AR and MA process. The ACF is shows the moving average (MA) process which indicates the current variation (error) effected by the previous lag. The PACF shows the autoregressive process (AR) which shows that the current observation effected by lag value. The first lag in all the cases is significant.

Now we check the distribution of series with the reference of normal distribution.

Figure 3.4- The Distribution of Return Series from 2007 to 2019



The figure 3.4 is about the distribution of all the return Series. The bars show the histogram of the data set or distribution of data in different categories. The blue line shows the normal distribution which is used to compare the actual distribution of data. The red line distributions are of actual distributions of return data series. The figure 4 clearly indicates that all the series have non normal distribution. The peak height of distributions is taller than reference normal distributions, which explains they are leptokurtic.

3.5 Summary of the Statistics

The initial summary statistics of return series contains location, scale parameters of distribution, four moments of distribution; mean, variance, skewness and kurtosis, ARCH test and stationary testing.

Table 3.1 - Summary of Statistics

Variables	KSE 100	Gold Price	Exchange Rate	Crude Oil Price
Mean	0.0004	0.0006	0.0003	0.0000
Standard Deviation	0.0117	0.0126	0.0040	0.0249
Skewness	-0.2246 (0.0000)	0.2091 (0.0000)	2.8019 (0.0000)	-0.0442 (0.31626)
Excess Kurtosis	3.9124 (0.0000)	7.7516 (0.0000)	78.5470 (0.0000)	5.4618 (0.0000)
Jarque-Bera	1989.60 (0.0000)	7731.10 (0.0000)	795540.00 (0.0000)	3827.80 (0.0000)
ARCH 1-2	180.56 (0.0000)	19.619 (0.0000)	14.534 (0.0000)	133.77 (0.0000)
Q Stat (5)	116.501 (0.0000)	14.191 (0.01444)	51.913 (0.0000)	6.57761 (0.25399)
Q Square (5)	730.164 (0.0000)	126.71 (0.0000)	41.97 (0.0000)	962.87 (0.0000)
KPSS	0.179571	0.2760	0.2418	0.0777

Note: KPSS test H0: series is I(0), Asymptotic critical values of KPSS (1% , 5%, 10%) = (0.739, 0.463, 0.347)Q-stat (n) auto correlation in return series H0: no serial correlation; Q2-stat (Q-stat on Squared Return series) H0: no serial correlation LM-ARCH(n) Lagrange multiplier test for ARCH effect up to order n, its H0: series is not subject to ARCH effect; JB (Jarque Bera)test H0: series is normal

The table 3.1 in chapter 3 displays the statistics of the return series. The mean value shows the mid value of data series. The averages of all the series are about to zero. The standard deviation shows the dispersion around the mid value of data. The deviations are also very low which indicates that low dispersion around the mean value. The skewness test is for to check the distance of tale from mid-point. If the distance of both tails from mean value is same then it is called symmetric distribution, otherwise asymmetric. The statistics of all the skewness tests are significant, whereas KSE 100 and crude oil price test statistics is negative it means that the negative tail of KSE 100 distribution and crude oil prices is greater than positive side.

So, it is negative skewed distribution. While all other distributions are positive skewed. The kurtosis tests statistics are significant it means the peak of the distributions of all the series is leptokurtic. The ARCH effect tests are indicating that there is ARCH effect in the series because all the statistics are significant.

The Jarque-Bera test is for the distributional normality test, the significant value of Jarque-Bera test is indicating that the distributions are non-normal. Q stat show the autoregressive pattern between observations. The test statistics are significant which mean that there is autoregressive behavior in the series. The Q Square test is to check the autoregressive behavior in squared return series. KPSS test shows all the return series are stationary.

Chapter 4

Results and Discussion

This chapter contains the outputs of return and volatility co-movements effect particularly, the contemporaneous and lag volatility spillover which are attained by employing the GARCH and ARDL GARCH models. The first section of chapter based on data visualization of raw data, return series and distributional properties. The second section is contained descriptive analysis. The third section is based on contemporaneous mean spillover effect and time lag mean spillover effect which is measured by using conditional mean equation. The fourth section of this chapter is about the contemporaneous volatility spillover effect and time lag volatility spillover effect which is measured by using conditional variance equation.

4.1 The Volatility Modeling of Return Series

This section is based on the volatility modeling of the return series of KSE100 Gold prices Exchange rate and Crude oil. For volatility series we have estimated the volatility of all series through GARCH type modeling because we see in data visualization and in descriptive statistics, they indicate that there is ARCH effect in return series.

Table 4.1 - Volatility Modeling of Return Series of KSE 100

	Coefficient	Std.Error	t-value	t-prob
Conditional Mean Equation				
Cst(M)	0.0005	0.00022	2.802	0.0051
AR (1)	0.9572	0.1148	7.441	0.0000
AR (2)	-0.1009	.03239	-3.763	0.0002
MA (1)	-0.7938	0.1182	-6.717	.00000
Conditional Variance Equation				
Cst(V) x 10^6	0.0483	0.0147	3.282	0.001
ARCH(Alpha1)	0.0660	0.0184	3.590	0.0000
GARCH(Beta1)	0.7938	0.0231	34.31	0.0000
GJR (Gemma)	0.2599	0.0450	5.776	0.0000
Student (DF)	5.2276	0.5208	10.04	0.0000
Persistence of Shock	0.8538			
Residual Analysis				
Skewness	**Excess Kurtosis**	**Q Stat (5)**	**Q Square Stat (5)**	**ARCH 1-2**
-0.50563 (0.0000)	4.1813 (0.0000)	3.9412 (0.1393)	4.6550 (0.1988)	0.5790 (0.5605)

Table 4.1 show the results of KSE 100 index volatility modeling. The conditional mean equation KSE 100 index is showing the data generating process of return series. The constant of conditional mean equation is significant which show if all other variables are equal to zero

then mean value of conditional mean equation is 0.0005. The autoregressive term and moving average term show ARMA (2, 1) process.

The GJR model is asymmetric model which shows that the conditional variance equation of KSE 100 is having asymmetric effect. The specification of the variance equation is GJR (1, 1). The ARCH and the GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term. The GJR term is also significant it means the ARCH term has special effect. The t-student distribution is used for the estimation of volatility modeling because the distribution coefficient is also significant. The persistence of shock show that how much time the shock will persist in return series. Its range is between 0 to1. The value about to 1 explains that extensive time is required for the decline of ARCH and GARCH consequence and vice versa. Its value is 0.8538 which is near to 1 means both effects take long time to decline.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance. The ARCH effect shows that the model is good fit and its capture the ARCH effect from residuals.

Table 4.2- Volatility Modeling of Return Series of Gold Prices

	Coefficient	Std.Error	t-value	t-prob
Conditional Mean Equation				
Cst(M)	0.0004	0.00015	4.736	0.0017
AR (1)	0.5641	0.1028	14.57	.0000
MA (1)	-0.6279	.0098	-5.259	.0000
MA (2)	0.0480	0.0172	2.791	0.0053
Conditional Variance Equation				
Cst(V) x 10^6	0.01486	0.00472	3.147	0.0017
ARCH(Alpha1)	0.0424	0.00736	5.764	0.0000
GARCH(Beta1)	0.9494	0.00798	118.9	0.0000
Student (DF)	4.1345	0.3299	12.53	0.0000
Persistence of shock	0.9918	--------	--------	--------
Residual Analysis				
Skewness	**Excess Kurtosis**	**Q Stat (5)**	**Q Square Stat (5)**	**ARCH 1-2**
0.3233 (0.0000)	6.7847 (0.0000)	4.5843 (0.1010)	(5.7618) (0.1237)	2.5299 (0.0798)

Table 4.2 show the results of Gold prices volatility modeling. The conditional mean equation of Gold prices is showing the data generating process of return series. The constant of conditional mean equation is significant which shows if slopes of other variables are zero then average value of return equation is 0.0004. The AR and MA terms shows ARMA (1,2) process.

The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term. The t-student distribution is used for the estimation of volatility modeling because the distribution coefficient is also significant. The persistence of shock value is 0.9918 which is close to 1 indicates that both effects take long time to decline.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance. The ARCH effect shows that the model is good fit and its capture the ARCH effect from residuals.

Table 4.3 - Volatility Modeling of Return Series of Exchange Rate

	Coefficient	Std.Error	t-value	t-prob
Conditional Mean Equation				
Cst(M)	-0.00366	0.0000017	-47.32	0.0000
AR (1)	0.1253	0.0375	3.333	0.0000
AR (2)	0.1337	0.0266	5.010	0.0000
AR (3)	0.13548	0.0253	5.344	0.0000
MA (1)	0.0925	0.0297	3.108	0.0019
Conditional Variance Equation				
Cst(V) x 10^6	0.0169	0.0267	0.6338	0.5263
ARCH(Alpha1)	0.0983	0.0267	3.669	0.0002
GARCH(Beta1)	0.87446	0.0372	23.47	0.0000
Student (DF)	6.0026	0.2948	20.36	0.0000
Persistence of shock	0.972			
Residual Analysis				
Skewness	**Excess Kurtosis**	**Q Stat (5)**	**Q Square Stat (5)**	**ARCH 1-2**
-2.4405 (0.0000)	60.247 (0.0000)	2.223 (0.2301)	0.6263 (0.8903)	0.0828 (0.9205)

Table 4.3 show the results of Exchange rate volatility modeling. The conditional mean equation Exchange rate is showing the data generating process of return series.

The constant of conditional mean equation is significant which show if all other variables are equal to zero then then mean value of conditional mean equation is -0.0036. The autoregressive term and moving average term show that the ARMA (3, 1) process.

The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term. The t-student distribution is used for the estimation of volatility modeling because the distribution coefficient is also significant. The persistence of shock value is 0.972 is near to 1 means the both effects decline in long time.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance. The ARCH effect shows that the model is good fit and its capture the ARCH effect from residuals.

Table 4.4- Volatility Modeling of Return Series of Crude Oil

	Coefficient	Std.Error	t-value	t-prob
Conditional Mean Equation				
Cst(M)	-0.000939	0.00031401	-2.989	0.0028
AR (1)	-0.7954	0.1670	-4.762	0.0000
MA (1)	0.7773	0.1733	4.483	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.03003	0.01147	2.618	0.0054
ARCH(Alpha1)	0.0128	0.0109	1.175	0.2400
GARCH(Beta1)	0.9425	0.0117	80.10	0.0000
GJR(Gemma1)	0.0882	0.01434	6.153	0.0000
Student (DF)	6.7895	0.84623	8.023	0.0000
Persistence of shock	0.944			
Residual Analysis				
Skewness	**Excess Kurtosis**	**Q Stat (5)**	**Q Square Stat (5)**	**ARCH 1-2**
0.007360 (0.0347)	1.5379 (0.0000)	3.2505 (0.35459)	13.0629 (0.095)	3.5074 (0.0983)

Table 4.4 show the results of Crude oil prices volatility modeling. The conditional mean equation Crude oil prices is showing the data generating process of return series.

The constant of conditional mean equation is significant which show if all other changes are equal to zero then the average value of return equation is -0.0009. The autoregressive term and moving average term show that the ARMA (1, 1) process.

The ARCH coefficient and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term. The t-student distribution is used for the estimation of volatility modeling because the distribution coefficient is also significant. The persistence of shock value is 0.944 which is close to 1, it means both effects take long time for decay.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance. The ARCH effect shows that the model is good fit and its capture the ARCH effect from residuals.

4.2 Tracing out the Contemporaneous and Lag Mean Spillover effect

This section is based on the estimations of contemporaneous and lag mean spillover effect. According to Hamao et al. (1990) put the return and lag return series of one market in the Conditional mean equation of other market, if the results are statistically significant, it means there is contemporaneous, and lag mean spillover effect.

Table 4.5- Tracing out Contemporaneous and lag mean Spillover Effect between Gold Price and Exchange Rate

	Exchange rate to Gold Price		Gold Price to Exchange rate	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000392	0.0296	0.000182	0.0001
Mean Spillover	0.553823	0.0000	0.023171	0.0000
Lag Mean Spillover	0.249008	0.0147	-0.003799	0.3150
AR (1)	-0.088808	0.0001	-0.698553	0.0179
AR (2)	----------	---------	-0.102730	0.0028
MA (1)	----------	----------	0.600248	0.0515
Conditional Variance Equation				
Cst(V) x 10^4	0.001986	0.0000	0.000291	0.0000
ARCH(Alpha1)	0.287844	0.0000	0.162796	0.0000
GARCH(Beta1)	0.944819	0.0000	0.983810	0.0000
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Exchange rate to Gold	1650.8 (0.00000)	3.53100 (0.6187022)	14.0185 (0.064925)	4.3616 (0.39960)
GARCH (1, 1) Gold to Exchange rate	6.1543e+005 (0.00000)	18.2269 (0.066751)	5.21839 (0.3898133)	4.3616 (0.00000)

Table 4.5 shows the results of cross return spillover and lag mean spillover between Gold prices and Exchange rate. The second column of table shows the results of mean spillover and lag mean spillover from Exchange rate to Gold prices. The constant of conditional mean

equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000392. The autoregressive term and moving average term show ARMA (1, 0) process. The both terms mean spillover effect and lag mean spillover effect are significant which indicates that is information transmit with lag and have simultaneous effect due to significant mean spillover term.

In third column of table 4.5 shows mean spillover effect and lag mean spillover effect from Gold prices to exchange rate. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000182. The autoregressive term and moving average term show ARMA (2, 1) process. The term mean spillover effect is significant and the term lag mean spillover effect is insignificant. The term lag mean spillover effect is insignificant which indicates that no information transmits with lag, but there is simultaneous effect due to significant mean spillover term, that is Gold prices return has a simultaneous impact on Exchange Rate returns. In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.6- Tracing out Contemporaneous and lag Mean spillover effect between KSE 100 and Exchange Rate

	KSE 100 to Exchange Rate		Exchange Rate to KSE100	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000222	0.0002	0.001020	0.0000
mean spillover	----------	----------	-0.142021	0.1132
Lag Mean Spillover	-0.021882	0.0349	-0.020870	0.7698
AR (1)	-0.715663	0.0412	1.039663	0.0000
AR (2)	-0.110652	0.0013	-0.12763	0.0000
MA (1)	0.607915	0.0969	-0.88512	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.000290	0.0000	0.002532	0.0000
ARCH(Alpha1)	0.166733	0.0000	0.373812	0.0000
GARCH(Beta1)	0.983367	0.0000	0.901199	0.0000
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1, 1) KSE 100 To Exchange rate	6.0674e+005 (0.0000)	18.2108 (0.2693)	5.62463 (0.3444727)	4.3485 (0.0000)
GARCH (1, 1) Exchange Rate to KSE100	967.21 (0.0000)	4.77418 (0.4440569)	8.02481 (0.1548738)	-0.38638 (0.0000)

Table 4.6 shows the results of cross mean return and lag mean spillover effect between KSE 100 and Exchange rate. The second column of table shows the results of spillover from KSE100 to Exchange Rate. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is

0.000222. The autoregressive term and moving average term show ARMA (2, 1) process. The term lag mean spillover effect is significant which indicates that there is information transmit with lag, In third column of table 4.6 shows mean spillover and lag mean spillover effect from Exchange rate to KSE100. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.001020. The autoregressive term and moving average term show ARMA (2, 1) process. The mean spillover term and lag mean spillover effect are insignificant which shows that there is no simultaneous effect as well as no information transmit with lag, that's KSE100 return has no impact on Exchange rate. In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.7- Tracing out Contemporaneous and lag mean spillover Crude Oil Prices and KSE 100

	Crude Oil to KSE 100		KSE 100 to Crude Oil	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000976	0.00000	0.000596	0.0122
mean spillover	0.006385	0.4258	-0.017346	0.6584
Lag mean Spillover	0.017820	0.0164	-0.016478	0.6577
AR (1)	1.040106	0.00000	-1.851625	0.0000
AR (2)	-0.127189	0.00000	-0.887940	0.0000
MA (1)	-0.885485	0000	1.835485	0.0000
MA (2)	----------	------	0.872680	0.0001
Conditional Variance Equation				
Cst(V) x 10^4	0.002575	0.0000	0.002231	0.0000
ARCH(Alpha1)	0.371155	0.0000	0.262865	0.0000
GARCH(Beta1)	0.900943	0.0000	0.961114	0.0000
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Crude Oil to KSE 100	1167.7 (0.0000)	4.71654 (0.4514439)	6.87577 (0.2300449)	-0.42517 (0.0000)
GARCH (1, 1) KSE 100 to Crude Oil	836.69 (0.0000)	0.614540 (0.9873278)	5.40878 (0.3680518)	-0.19635 (0.0000)

Table 4.7 shows the results of cross mean return spillover and lag mean spillover effect between Crude oil prices and KSE100. The second column of table shows the results of

spillover from Crude oil to KSE100. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000976. The autoregressive term and moving average term show ARMA (2, 1) process. The term lag mean spillover effect is significant which indicates that information transmits with lag, it does have simultaneous effect from Crude oil to KSE100. That is the return of Crude oil has no effect on returns of KSE100, but the lag returns of Crude oil effect return of KSE100. In third column of table 4.7 shows mean spillover and lag mean spillover effect from KSE100 to Crude oil. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000596. The autoregressive term and moving average term show ARMA (2, 2) process. The mean spillover term and lag mean spillover effect are insignificant which shows that there is no simultaneous effect as well as no information transmit with lag, that is KSE100 return has no impact on Crude oil returns.

In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.8- Tracing out Contemporaneous and lag Mean Spillover Effect between Crude Oil and Gold Prices

	Gold to Crude Oil		Crude Oil to Gold	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.00052	0.0177	-0.00057	0.0039
mean spillover	0.356483	0.0000	0.096553	0.0000
Lag mean Spillover	0.032577	0.2708	0.002765	0.7916
AR (1)	-1.639568	0.0000	-0.072107	0.0017
AR (2)	-0.686449	0.0000	----------	----------
MA (1)	1.619503	0.0000	----------	----------
MA (2)	0.670047	0.0001	----------	----------
Conditional Variance Equation				
Cst(V) x 10^4	0.002244	0.0000	0.001932	0.0127
ARCH(Alpha1)	0.262111	0.0000	0.246144	0.0008
GARCH(Beta1)	0.960948	0.0000	0.956555	0.0000
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Gold Price to Crude Oil	905.39 (0.0000)	1.01651 (0.9612230)	7.12747 (0.2113313)	-0.24122 (0.0000)
GARCH (1, 1) Crude Oil to Gold Price	5798.3 (0.00000)	5.02380 (0.4129825)	3.02889 (0.6955318)	0.43923 (0.0000)

Table 4.8 shows the results of cross return spillover and lag mean spillover effect between Crude Oil and Gold Price. The second column of table shows the results of spillover between Gold Price to Crude Oil. The constant of conditional mean equation is significant

which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000523. The autoregressive term and moving average term show ARMA (2, 2) process. The term mean spillover effect is significant which indicates That the return of gold prices has effect on the returns of Crude Oil but lag mean spillover effect is insignificant which shows there is no lag mean spillover effect from gold prices to exchange rate.

In third column of table shows mean spillover and lag mean spillover effect from Crude oil to Gold prices. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is -0.00057. The autoregressive term and moving average term show ARMA (1, 0) process. The mean spillover effect term is significant, and the term lag mean spillover effect is insignificant which shows that there is a simultaneous effect, but no information transmits with lag, that is Crude oil return has impact on Gold Price return. In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.9- Tracing out Contemporaneous and lag Mean Spillover Effect between Gold Price and KSE 100

	KSE 100 to Gold		Gold to KSE100	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000645	0.0017	0.000983	0.0000
Mean Spillover	----------	----------	-0.010977	0.5121
Lag Mean Spillover	-0.033178	0.0952	-0.017832	0.3548
AR (1)	-0.06537	0.0033	1.047950	0.0000
AR (2)	----------	----------	-0.130265	0.0000
MA (1)	----------	----------	-0.890543	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.001775	0.0013	0.002525	0.0000
ARCH(Alpha1)	0.227476	0.0000	0.373617	0.0000
GARCH(Beta1)	0.963296	0.0000	0.901544	0.0000
Residual Analysis				
	Skewness	**Q Stat (5)**	**Q Square Stat (5)**	**Jarque-Bera**
GARCH (1,1) KSE 100 to Gold	0.33122 (0.0000)	4.77189 (0.3115141)	3.10788 (0.3752900)	5409.0 (0.0000)
GARCH (1, 1) Gold to KSE100	-0.40238 (0.0000)	4.63820 (0.4616083)	7.49436 (0.1863926)	1010.3 (0.0000)

Table 4.9 shows the results of cross return spillover and lag mean spillover between Gold prices and KSE 100. The second column of table shows the results of mean and lag mean spillover effect from KSE 100 index to gold prices. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000645. The autoregressive term and moving average shows ARMA (1, 0)

process. The term lag mean spillover effect is insignificant which indicates that information transmits with lag, it does not have simultaneous effect.

In third column of table 4.9 shows mean spillover effect from Gold prices to KSE 100. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000983. The autoregressive term and moving average term show ARMA (2, 1) process. The mean spillover term and lag mean spillover effect are insignificant which shows that there is no simultaneous effect as well as no information transmit with lag, that's Gold Prices returns has no impact on KSE 100 returns.

In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.
The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.10-Tracing out Contemporaneous and lag mean spillover between Crude Oil and Exchange Rate

	Crude Oil to exchange rate		Exchange Rate to crude oil	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000193	0.0002	0.000556	0.01449
mean spillover	-0.002108	0.3248	0.036730	0.7411
Lag Mean Spillover	-0.001689	0.3480	0.016299	0.8969
AR (1)	-0.748205	0.0209	-1.858090	0.0000
AR (2)	-0.103772	0.0030	-0.893917	0.0000
MA (1)	0.652674	0.0546	1.842305	0.0000
MA (2)	----------	----------	0.878896	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.000300	0.0000	0.002226	0.0000
ARCH(Alpha1)	0.166453	0.0000	0.262125	0.0000
GARCH(Beta1)	0.983078	0.0000	0.961321	0.0000
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Crude Oil to exchange rate	6.2882e+005 (00000)	18.7769 (0.21149)	5.44496 (0.3640192)	4.4009 (00000)
GARCH (1, 1) Exchange Rate to crude oil	837.26 (0.0000)	0.492715 (0.9923876)	5.57837 (0.3494283)	-0.19541 (0.0000)

Table 4.10 shows the results of cross return spillover and lag return spillover between Crude oil and Exchange rate. The second column of table shows the results of spillover between from Crude oil to Exchange Rate. The constant of conditional mean equation is significant

which show if all slopes are equal to zero then the average value of conditional mean equation is -0.000193. The autoregressive term and moving average term show ARMA (2, 1) process. The term means spillover and lag mean spillover effect is insignificant which indicates that information transmit does not exist as well as no simultaneous effect from Crude oil to Exchange Rate. That is the return of Crude Oil has no effect on returns of Exchange Rate.

In third column of table 4.10 shows mean spillover effect and lag mean spillover effect from Exchange rate to Crude oil. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is 0.000556. The autoregressive term and moving average term show ARMA (2, 2) process. The mean spillover term and lag mean spillover effect are insignificant which shows that there is no simultaneous effect as well as no information transmit with lag, that is there is no mean and lag mean spillover effect from Exchange Rate to Crude oil. In conditional variance equation. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

4.3 Tracing out the Contemporaneous and Lag Volatility Spillover Effect

This section contains the results of contemporaneous and previous period variation co-movement. According to Hamao et al. (1992) put the volatility and lag volatility series of one market in the Conditional variance equation of other market, if the results are statistically significant, it means there is contemporaneous and lag volatility spillover effect.

Table 4.11- Tracing out Contemporaneous and Lag Volatility Spillover Effect between Exchange rate and KSE 100

	Exchange rate to KSE 100		KSE 100 to Exchange rate	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.001008	0.0000	0.000156	0.0002
AR (1)	1.045059	0.0000	-0.679306	0.0128
AR (2)	-0.131150	0.0000	-0.101372	0.0038
MA (1)	-0.883714	0.0000	0.580778	0.0412
Conditional Variance Equation				
Cst(V) x 10^4	0.002251	0.0000	0.000000	0.1727
ARCH(Alpha1)	0.383599	0.0000	0.173772	0.0003
GARCH(Beta1)	0.885962	0.0000	0.981108	0.0000
Volatility Spillover	0.047651	0.7411	0.003654	0.0395
Lag Volatility Spillover	-0.000002	0.0138	0.000010	0.0234
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Exchange rate to KSE 100	594.21 (0.0000)	3.47532 (0.6271259)	8.75442 (0.1192698)	-0.32805 (0.0000)
GARCH (1, 1) KSE 100 to Exchange rate	4.9253e+005 (0.00000)	22.6472 (0.39445)	5.41608 (0.3672359)	4.0873 (0.00000)

Table 4.11 shows the results of Contemporaneous and Lag volatility Spillover between Exchange rate and KSE 100. The second column of table shows the results of volatility spillover and lag volatility spillover from to Exchange rate to KSE100. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the

average value of conditional mean equation is constant value. The autoregressive term and moving average term show ARMA (2, 1) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from Exchange rate to KSE 100 index. In other words, the volatility of Exchange rate has no effect on volatility of KSE 100 index. Lag volatility spillover term is significant it shows that there is lag volatility spillover effect from exchange rate to KSE 100 which means that lag value of volatility Exchange rate has effect on volatility of KSE 100.The term lag mean spillover effect is significant which indicates that information transmit with lag, but there is no simultaneous effect due to insignificant volatility spillover term.

The third column of Table 4.11 shows the results of Contemporaneous and Lag volatility Spillover from KSE 100 to Exchange rate. The constant of conditional mean equation is significant which show if all slopes are near to zero then the average value of conditional mean equation is constant value. The autoregressive term and moving average term show that the ARMA (2, 1) process. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover term is significant which indicates that there is volatility spillover effect from KSE 100 to Exchange rate. In other words, the volatility of KSE 100 has effect on volatility of Exchange rate. Lag volatility spillover term is also significant it shows that there is lag volatility spillover effect from KSE 100 to Exchange rate. It also means that lag value of volatility of KSE 100 has information with lag effect on volatility of Exchange rate. The term lag volatility spillover effect is significant which indicates that information transmits with lag, also have simultaneous effect due to significant value of volatility spillover effect.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.12-Tracing out Contemporaneous and Lag Volatility Spillover Effect between Exchange rate and Gold Prices

	Gold to Exchange rate		**Exchange rate to Gold**	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.0002	0.0021	0.000578	0.0022
AR (1)	0.8472	0.0000	-0.068591	0.0016
AR (2)	0.1051	0.0045	----------	----------
MA (1)	-0.9443	0.0000	----------	----------
Conditional Variance Equation				
Cst(V) x 10^4	0.0003	0.0000	0.002075	0.0126
ARCH(Alpha1)	0.1660	0.0000	0.297816	0.0000
GARCH(Beta1)	0.9830	0.0000	0.922908	0.0000
Volatility Spillover	-0.0002	0.0127	----------	---------
Lag Volatility Spillover	-0.00001	0.0081	-0.054464	0.0027
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Gold to Exchange rate	6.27e+005 (0.0000)	15.69 (0.77644)	5.278 (0.3823)	4.3545 (0.0000)
GARCH (1, 1) Exchange rate to Gold	1754.5 (0.00000)	4.81747 (0.4385600)	4.15809 (0.5268871)	0.036867 (0.40348)

Table 4.12 shows the results of Contemporaneous and Lag volatility Spillover between Gold price and Exchange rate. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is

constant value. The autoregressive term and moving average term show ARMA (2, 1) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is significant which indicates that there is volatility spillover effect from Gold prices to Exchange rate. In other words, the volatility of Gold price return has effect on volatility of exchange rate. Lag volatility spillover term is also significant it shows that there is lag volatility spillover effect from Gold prices to exchange rate which means that lag value of volatility Gold prices has effect on volatility of exchange rate.

Third column of table 4.12 shows the results of Contemporaneous and Lag volatility Spillover from Exchange rate to Gold price. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is constant value. The autoregressive term and moving average term show ARMA (1, 0) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from Exchange rate to Gold price. Lag volatility spillover term is significant it shows that there is lag volatility spillover effect from Exchange rate to Gold price which means that lag value of volatility exchange rate has effect on volatility of Gold Price.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.13- Tracing out Contemporaneous and Lag Volatility Spillover Effect between Exchange rate and Crude Oil Price

	Crude oil to Exchange rate		Exchange rate to crude oil	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000189	0.0002	0.000563	0.1256
AR (1)	-0.741268	0.0142	-1.849757	0.0000
AR (2)	-0.104900	0.0025	-0.886109	0.0000
MA (1)	0.644452	0.0422	1.833741	0.0000
MA (2)	----------	----------	0.871073	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.0003	0.0000	0.0019	0.0011
ARCH(Alpha1)	0.1661	0.0000	0.2596	0.0000
GARCH(Beta1)	0.9830	0.0000	0.9606	0.0000
Volatility Spillover	-0.00001	0.0714	----------	---------
Lag Volatility Spillover	-0.0002	0.0143	0.036906	0.0017
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Crude to Exchange rate	6.2563e+005 (0.000)	18.7765 (0.53211)	5.48660 (0.3594)	4.3970 (0.000)
GARCH (1, 1) Exchange rate to crude oil	797.13 (0.0000)	0.465763 (0.99332)	5.6334 (0.3435)	-0.18736 (0.0000)

Table 4.13 shows the results of Contemporaneous and Lag volatility Spillover between Crude oil and exchange rate. The second column of table shows volatility spillover and lag volatility spillover effect from crude oil to exchange rate the constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of

conditional mean equation is constant value. The autoregressive term and moving average term are significant which shows ARMA (2, 1) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from Crude oil to Exchange rate. In other words, the volatility of crude oil return has no effect on volatility of exchange oil. Lag volatility spillover term is significant it shows that there is lag volatility spillover effect from crude oil to exchange rate which means that lag value of volatility of Crude oil has effect on volatility of exchange rate. The term lag mean spillover effect is significant which indicates that information transmits with lag, but there is no simultaneous effect due to insignificant volatility spillover term.

Third column of Table shows the results of Contemporaneous and Lag volatility Spillover from exchange rate to crude oil. The constant of conditional mean equation is insignificant which show if all slopes are equal to zero then the average value of conditional mean equation is not constant value. The autoregressive term and moving average term show ARMA (2, 2) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from exchange rate to crude oil. In other words, the volatility of exchange rate return has no effect on volatility of crude oil. Lag volatility spillover term is significant it shows that there is lag volatility spillover effect from exchange rate to crude oil which means that lag value of volatility of exchange rate has effect on volatility of crude oil. The term lag volatility spillover effect is significant which indicates that there is information transmit with lag, but

there is no simultaneous effect. The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals.

Table 4.14- Tracing out Contemporaneous and Lag Volatility Spillover Effect between Gold Prices and Crude Oil

	Gold to Crude Oil		Crude Oil to Gold	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000578	0.1347	0.000584	0.0019
AR (1)	-1.857709	0.0000	-0.065545	0.0018
AR (2)	-0.893466	0.0000	----------	----------
MA (1)	1.842080	0.0000	----------	----------
MA (2)	0.878485	0.0000	----------	----------
Conditional Variance Equation				
Cst(V) x 10^4	0.000693	0.6693	0.004074	0.0004
ARCH(Alpha1)	0.268035	0.0000	0.390814	0.0000
GARCH(Beta1)	0.956919	0.0000	0.697348	0.0000
Volatility Spillover	-0.029005	0.0016	0.047455	0.0000
Lag Volatility Spillover	0.000015	0.0000	-0.000001	0.2022
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Gold to Crude Oil	805.82 (0.0000)	0.624786 (0.9868403)	4.63522 (0.4619978)	-0.1979 (0.0000)
GARCH (1, 1) Crude Oil to Gold	2132.6 (0.0000)	3.15050 (0.6767)	2.34649 (0.7994)	0.14809 (0.0007)

Table 4.14 shows the results of Contemporaneous and Lag volatility Spillover between Gold price and Crude Oil. The second column of the table shows volatility and lag volatility spillover effect from gold prices to crude oil prices. The constant of conditional mean equation

is insignificant which show if all slopes are equal to zero then the average value of conditional mean equation is no constant value. The autoregressive term is and moving average term shows ARMA (2, 2) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is significant which indicates that there is volatility spillover effect from Gold prices to Crude Oil. In other words, the volatility of Gold price has effect on volatility of Crude Oil. Lag volatility spillover term is also significant it shows that there is lag volatility spillover effect from Gold prices to Crude Oil which means that lag value of volatility Gold prices has effect on volatility of Crude Oil. The term lag mean spillover effect is significant which indicates that information transmits with lag, and the term volatility spillover shows simultaneous effect.

Third column of Table shows the results of Contemporaneous and Lag volatility Spillover from Crude oil to Gold Price. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is constant value. The autoregressive term is significant and moving average term is insignificant which shows ARMA (1, 0) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is significant which indicates that there is volatility spillover effect from Crude oil to Gold Price. In other words, the volatility of Crude Oil has effect on volatility of Gold Price. Lag volatility spillover term is insignificant it shows that there is no lag volatility spillover effect from Crude oil to Gold Price which means that lag value of volatility of Crude oil has no effect on volatility of Gold Price. The term lag volatility spillover

effect is insignificant which indicates that no information transmits with lag, there is only simultaneous effect due to significant volatility spillover term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.15- Tracing out Contemporaneous and Lag Volatility Spillover Effect between Crude Oil and KSE 100

	Crude Oil to KSE 100		**KSE 100 to Crude Oil**	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.000993	0.0000	0.000577	0.1168
AR (1)	1.040911	0.0000	-1.851666	0.0000
AR (2)	-0.128255	0.0000	-0.887653	0.0000
MA (1)	-0.883811	0.0000	1.836426	0.0000
MA (2)	----------	----------	0.873355	0.0000
Conditional Variance Equation				
Cst(V) x 10^4	0.002367	0.0000	0.000014	0.7689
ARCH(Alpha1)	0.374431	0.0000	0.267910	0.0000
GARCH(Beta1)	0.901573	0.0000	0.956652	0.0000
Volatility Spillover	0.006617	0.4330	-0.031429	0.0000
Lag Volatility Spillover	-0.000074	0.8939	-0.000002	0.0072
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Crude Oil to KSE 100	908.38 (0.0000)	4.48789 (0.4815057)	7.27629 (0.2008900)	-0.38882 (0.0000)
GARCH (1, 1) KSE 100 to Crude Oil	765.15 (0.0000)	0.526498 (0.9911209)	5.91887 (0.3141936)	-0.19828 (0.0000)

Table 4.15 shows the results of Contemporaneous and Lag volatility Spillover between Crude Oil and KSE 100.the second column of table shows volatility and lag volatility from Crude oil to KSE 100.The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is constant value. The autoregressive term and moving average term show ARMA (2, 1) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from Crude Oil to KSE 100 index. In other words, the volatility of Crude Oil has no effect on volatility of KSE 100 index. The term Lag volatility spillover term is also insignificant it shows that lag volatility spillover does not affect from Crude oil KSE 100 which means that lag value of volatility of Crude Oil has no effect on volatility of KSE 100. The term lag volatility spillover effect is insignificant which indicates that no information transmits with lag, it also does not have no simultaneous effect due to insignificant volatility spillover term.
The third column shows the results of Contemporaneous and Lag volatility Spillover from KSE 100 to Crude Oil. The constant of conditional mean equation is insignificant which show if all slopes are equal to zero then the average value of conditional mean equation is not a constant value. The autoregressive term and moving average term show ARMA (2, 2) process. The constant term of conditional variance equation is insignificant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is significant which indicates that there is volatility spillover effect from KSE 100 to Crude Oil. In other words, the volatility of KSE 100 index has effect on volatility of Crude Oil. Lag volatility spillover term is also significant it shows that there is

lag volatility spillover effect from KSE 100 to Crude Oil which means that lag value of volatility KSE 100 influences volatility of Crude Oil. The term lag volatility spillover effect is significant which indicates that information transmits with lag, it also have simultaneous effect due to significant volatility spillover term.

The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

Table 4.16- Tracing out Contemporaneous and Lag Volatility Spillover Effect between Gold Prices and KSE 100

	Gold to KSE 100		**KSE 100 to Gold**	
	Coefficient	**t-prob**	**Coefficient**	**t-prob**
Conditional Mean Equation				
Cst(M)	0.00100	0.0000	0.000622	0.0024
AR (1)	1.0395	0.0000	-0.065374	0.0029
AR (2)	-0.1290	0.0000	----------	---------
MA (1)	-0.8815	0.0000	----------	---------
Conditional Variance Equation				
Cst(V) x 10^4	0.0021	0.0000	0.001450	0.0417
ARCH(Alpha1)	0.3791	0.0000	0.237929	0.0004
GARCH(Beta1)	0.8994	0.0000	0.956449	0.0000
Volatility Spillover	0.01501	0.1166	-0.016960	0.0727
Lag Volatility Spillover	0.00005	0.3646	-0.000184	0.2106
Residual Analysis				
	Jarque-Bera	**Q Stat (5)**	**Q Square Stat (5)**	**Skewness**
GARCH (1,1) Gold to KSE 100	771.72 (0.000)	4.39567 (0.4939621)	8.10166 (0.1507210)	-0.36949 (0.000)
GARCH (1, 1) KSE 100 to Gold	4873.3 (0.000)	4.60092 (0.4664947)	3.21695 (0.6665787)	0.30403 (0.000)

Table 4.16 shows the results of Contemporaneous and Lag volatility Spillover between Gold price and KSE 100.The second column of table shows the results of volatility spillover and lag volatility spillover from Gold prices to KSE100. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is constant value. The autoregressive term and moving average term show ARMA (2, 1) process. The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term.

The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from Gold prices to KSE 100 index. In other words, the volatility of Gold price return has no effect on volatility of KSE 100 index. The term Lag volatility spillover effect is also insignificant it shows that there is no lag volatility spillover effect from Gold prices to KSE 100 which means that lag value of volatility Gold prices has no effect on volatility of KSE 100. The term lag mean spillover effect is insignificant which indicates that no information transmits with lag, and no simultaneous effect due to insignificant volatility spillover term.
The third column shows the results of Contemporaneous and Lag volatility Spillover from KSE 100 to Gold Price. The constant of conditional mean equation is significant which show if all slopes are equal to zero then the average value of conditional mean equation is constant value. The autoregressive term and moving average term show ARMA (1, 0) process.

The constant term of conditional variance equation is significant. The ARCH and GARCH coefficients are significant which indicate that the variance is depending on its own lag value too along ARCH term. The term volatility spillover is insignificant which indicates that there is no volatility spillover effect from KSE 100 to Gold Price. In other words, the volatility of KSE 100 return has no effect on volatility of Gold Price. Lag volatility spillover term is also insignificant it shows that there is no lag volatility spillover effect from KSE 100

to Gold Price. The term lag volatility spillover effect is insignificant which indicates that there is no information transmit with lag, and there is no simultaneous effect due to insignificant volatility spillover term. The residual analysis is employed to validate the results the Q stat shows there is no autocorrelation in residuals. The Q Square shows there is no auto correlation in variance.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The purpose of study is to explore the mean and dynamic linkages spillover effects among the commodity, stock and forex markets. The gold and crude oil prices are from commodity market, the exchange rate from forex and KSE 100 index is from Pakistan stock exchange. There is plethora of studies which had been explored the linkages among commodity, stock and forex markets partially. But we are unable to find out any on the linkages among these markets because we reviewed many studies in literature review section which focused on the linkages among these markets. So, this study is contributed in literature significantly in following ways: first it explores the mean and volatility linkages among commodity, stock and forex markets, second also explores the contemporaneous and as well as lag volatility spillover effects among markets.

The results conclude that the return series of KSE 100, Crude Oil prices has symmetric effect and Exchange Rate, Gold Prices having symmetric effect.

The results of contemporaneous and lag mean spillover effect indicate that there is contemporaneous, and lag means spillover effect between KSE 100 and gold prices. There is lag mean spillover effect from KSE100 to exchange rate, from crude oil to KSE100. There is bidirectional mean spillover effect between crude oil and gold prices, exchange rate and gold prices. There is no mean effect between exchange rate and gold prices, between crude oil and exchange rate, there is no mean spillover effect from exchange rate to KSE 100, from KSE100 to crude oil. There is no lag mean spillover effect between gold prices and KSE100, between crude oil and exchange rate, between crude oil and gold prices, there is no lag mean spillover effect from exchange rate to KSE100, from KSE100 to crude oil prices, from gold to exchange.

The results of contemporaneous and lag volatility spillover effect indicate that there is contemporaneous and time lag volatility spillover effect between KSE 100 and exchange rate, This shows that contemporaneous and time lag volatility spillover effect between crude oil and exchange rate contemporaneous and time lag volatility spillover effect between exchange rate and gold prices so we can say there is contemporaneous and lag volatility spillover effect from KSE 100 to crude oil prices ,from gold prices to crude oil prices. There is no lag volatility spillover effect between gold prices and KSE100, there is no lag volatility spillover effect from crude oil prices to KSE100, from crude oil prices to gold prices.

5.2 Policy Recommendation and Future Direction

The outputs of this study explore that there contemporaneous and lag mean, contemporaneous and lag volatility linkages among the series. So, the results of this study can help the portfolio investors market players and stake holders to understand these linkages and help to adjust the risks which are associated with investment.

These results may also help to policy makers of these markets to make an effective policy by analyzing these results. These results will be useful to investors to lookup risk management and enhance their portfolio returns through diversification of their stock risk on the basis of magnitude of the co-movements between different variable. It may help the public institution and regulatory authorities to understand that the shock in any market will affect the all other markets that is why they must make policy by considering these linkages.

The most important policy implications derived from these results is that the State Bank of Pakistan may monitor the impact of exchange rate and stock price fluctuations and its impact on both markets because the behavior of international portfolios is affected by the behavior of the two markets. Furthermore, if the policymakers want to stabilize the stock and foreign exchange markets and minimize the adverse effects of exchange rate and stock price volatilities

on investment decisions, they should design a policy that helps minimize the adverse impact of volatility. It is well known that the stability in the stock and foreign exchange markets is important to guarantee foreign direct and portfolio investments, which exert a positive impact on economic growth and enhance macroeconomic stability of the country. Such relationship may be useful in forecasting the behavior of Pakistan stock market both in short run and long run.

The Garch type model possess convergence problem we faced non convergence during this study there is a need to explore more sophisticated methods of parameter estimation in Garch type models. The proposed model may be employed to explore the meteor shower effect i.e. information transmission from outside the economy.

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