Multivariate Granger Causality among Oil prices, Gold prices, and KSE100: Evidence from Johansen Cointegration and GARCH Models

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3 authors:

Rizwan Raheem Ahmed
Indus University Karachi Pakistan

Jolita Vveinhardt
Vytautas Magnus University

Dalia Streimikiene
Lithuanian Energy Institute

Multivariate Granger Causality among Oil prices, Gold prices, and KSE100: Evidence from Johansen Cointegration and GARCH Models

Rizwan Raheem Ahmed[1], ***Jolita Vveinhardt***[2] *and* ***Dalia Streimikiene***[3]

The purpose of the research study is to examine the effect of changes in crude oil prices (COP) and gold prices (GP) and the long-run relationship of equity returns of KSE100 index. We have considered the sample period from January 1, 2010, through June 30, 2016, the KSE100 index daily data was obtained from the website of Pakistan stock exchange, and for COP and GP, we used the Yahoo Finance website. We employed descriptive statistics, correlation analysis, unit root test (ADF), multivariate cointegration, Granger causality, and ARCH & GARCH (1,1) time series models to perform the analysis.

Results of the study revealed an average daily return of stock prices is 9.85% with the volatility of 0.4676. Correlation analysis showed a significant negative association amidst equity returns, and crude oil and gold prices. By employing Johansen cointegration, we concluded that there is no long-run association has been observed amidst the equity returns, and crude oil and gold prices. The Granger causality test suggested one-way causation from COP to KSE100 at 5% level. The ARCH and GARCH (1,1) results revealed a cogent impact of COP on the returns volatility of KSE100 index.

Key words: *gold price, crude oil prices, KSE100 index, Johansen cointegration, ARCH & CARCH, Granger causality*

Introduction

Stock Markets are the barometer of the economic health of the economy and long-run sustainability. During the last decade, the stock markets and economies have witnessed massive upheavals and tremors. The unpredictable fluctuations in equity returns are trailed by reduced growth rates in an economy, as highlighted by Wei and Guo (2016) and Bhowmik (2013). Ma et al. (2016), and Engle and Patton (2001) have the view that financial asset prices do not evolve independently, so, it is likely that other factors might have enclosed vital evidence for the volatility of equity returns. Once we know which variables affect the volatility in the stock market, we can formulate strategies or policies to control these variables. Stock indices and returns are always being a great interest for arguments and association of stock indices with macroeconomic variables, and it is one of the most examined subjects for researchers and financial experts around the globe. This research measures the relationship among oil, gold and stock returns with exceptional reference to KSE100 index. The oil price showed a cogent impact for predicting prices of several industrial, and entrepreneurial costs, which eventually paved the way to determine the stock prices. Oil prices also influence almost every sphere of economy one way or the other. The oil price has become rationale fluctuation in earning capability of industrial and corporate concerns in an economy. More specifically the escalation in oil prices may cause a decline in earning capabilities of businesses concerns and/or vice verse. Rational evidence supports the stochastic association between stock and oil prices in an economy (Ghorbel & Souissi, 2016; Broadstock et al., 2016).

According to previous literature, there are several macroeconomic variables, which are responsible for the variation of equity returns, and changes in gold, and oil prices. These variations are imperative for investors' point of view. Numerous studies have been carried out to establish the association between gold prices and other economic indicators. According to Khan et al. (2016), Azar (2015), Toraman et al. (2011), Topcu (2010), Ghosh et al. (2004), Tully and Lucey (2005), and Koutsoyiannis (1983) gold is not a local product, therefore, the prices of gold influence the rate of exchange, oil prices, inflation, rate of interest, and equity returns etc. Since the dollar is used for the trade of gold, therefore, prices of gold directly influence the US policies; similarly, crude oil prices also affect the important variables and overall economy of the country. Same as other macroeconomic indicators for instance rate of inflation and interest, oil prices, and gold prices affect the equity returns (Raza et al., 2016; Najaf et al., 2016; Cheung et al., 1998; Gong & Mariano, 1997; Fama, 1981).

Mardini and Ali (2016) and Hu et al. (2016) have studied an association amidst oil prices and equity returns. They have concluded a positive and significant relationship between equity returns, economic growth, interest rate, and oil prices. It is an accepted fact that the financial markets play a cogent role in country's

[1] *Rizwan Raheem Ahmed,* Faculty of Management Sciences, Indus University, Block-17, Gulshan, Karachi-75300, Pakistan, rizwanraheemahmed@gmail.com
[2] *Jolita Vveinhardt,* Faculty of Economics and Management, Vytautas Magnus University, Daukanto str. 28, Lithuania, jolita.vveinhardt@gmail.com
[3] *Dalia Streimikiene,* Institute of Sport Science and Innovations, Lithuanian Sports University, Sporto str. 6, LT-4422, Lithuania, dalia.streimikiene@lei.lt

sustainable economy. This is also an important to comprehend that the variation in oil prices may cause changes in cost of doing business that indirectly hampers the inflation and interest rate, which further affect the equity returns of the business firms (Yurtkur et al., 2016; Naifar & Dohaiman, 2013; Driesprong et al., 2008; Pollet & Wilson, 2010). Similarly, crude oil is a backbone of the economy of any country. However, oil importing and oil exporting countries display different impacts while the crude oil prices increase or decrease. It is also observed that the variation in crude oil prices affects the rate of exchange, the rate of inflation, interest rates, and the equity returns (Broadstock et al., 2016; Wasseja, 2015; Hardouvelis, 1987). Sadorsky (1999), Nejad et al. (2016), and Levine (2003) have studied the impact of crude oil prices on the equity returns of the financial markets of Japan, the United States, the UK, and Canada. They have concluded a definite relationship between stock returns of these markets and crude oil prices; they established that the oil price is a major determinant for the sustainability of the economy and financial markets.

The objective of the research study

The research study aims to investigate the extent of linkages between crude oil and gold prices changes with the equity returns of KSE100 index. Another important objective of the research paper is to examine the causal association between the variations of crude oil and gold prices, and their impact on the returns of the Pakistan Stock market (KSE100). We have also taken care of gold and oil supply and demand factors and their impact on equity returns in the undertaken study. The analysis presumes to investigate the degree of relationship among gold, crude oil prices and KSE100 returns by utilizing Johansen cointegration, ARCH & GARCH (1,1), and Granger causality techniques. Another imperative point of the undertaken research study is to examine the effect of volatilities of the oil prices and gold prices on the equity returns of KSE100 index.

Significance and novelty of the research

The novelty and significance of the undertaken research study are multifarious. In recent past KSE100 index has witnessed incredible expansion and performance. Such exceptional performance of KSE100 distinguishes the market from its neighboring regional markets; this foundation has multiplied the significance of this study. Hefty developments are also observed in crude oil, and gold prices worldwide in general and Pakistan in particular. This has necessitated re-examining the association amidst equity returns, and crude oil prices and gold prices. The findings of this study will provide valuable investment decision input to the investors of a stock market. Numerous research paradigms are there, which confirmed oil and gold prices are the important variables that influence the equity returns. Hence the findings of this study are anticipated to provide valuable foundations to the stock investors. We have used high frequency (daily) data of the equity prices, and crude oil and gold prices for this research study that is more reliable while investigating an association amongst the economic indicators.

Gold trading markets in Pakistan

In Pakistan, there is a commodity market widely known as Pakistan Mercantile Exchange (PMEX), which further includes trade items of gold and commodities of variant nature. PMEX is actively offering services its target audience using e-sources 24-hours marketing and transactional services. The core commodities traded in the PMEX are crude oil, silver, and gold. There is a number of different contracts related to each commodity. There are eight contracts of gold, namely: mini-gold contracts, 100 gram, gold kilo, 100 *TOLA*, 50 *TOLA*, gold 1 *TOLA*, gold 100 ounces, and gold 1 ounce.

International crude oil prices

The spot prices of several barrels of oil are measured through crude oil prices, either Brent Blend or West Taxes Intermediate. Sometimes NMEX future and OPEC basket prices are also quoted. In Pakistani context, it can be easily observed that the cost of doing business and cost of production both in agriculture and manufacturing process is directly linked to the crude oil prices because of the oil importing country. As the economy of Pakistan mainly draws its substance from agrarian and textile products and the production cost in the identified segments are heavily influenced by the change in the prices of oil and gas. The prices of crude oil segregated according to its grade, which depends on the specific gravity and contents. The major classification is known as the sour crude oil, heavier, and lighter crude oil, etc.

Pakistan Stock Exchange (PSX)

Karachi stock exchange came into existence since September 18, 1947; at that time it was the sole equity market in Pakistan. It was a great milestone for KSE when it was announced one of the best financial markets in the world in 2002. The year 2016 was the great year for KSE when it regained the emerging market status once again. According to the internationally reputed financial magazine, Bloomberg has announced the 3rd best performing equity market for the year 2014 amongst other 10 markets. There was a transformation in Pakistani equity markets, and Pakistan stock exchange has come into existed since January 11, 2016, and other two markets, for instance, LSE and ISE have been merged into KSE and renamed it Pakistan stock exchange (PSX). PSX is regarded as one of the largest equity markets of South Asia. PSX comprises of 654 listed companies with total market capitalization of USD72 billion as of July 2015 and now reached up to USD120.5 billion in 2016 (Pakistan stock exchange, 2016).

The residue of the research paper is composed as: Segment 2 outlines the significant financial literature on the connection between crude oil prices, gold prices, essential economic factors, and capital markets. Segment III defines the empirical framework and estimation techniques. Segment IV consisted of estimations and results of the research study. However, Segment V comprises of discussions and conclusion.

Substantiation from previous literature

The association amidst equity returns and economic indicators is one of the most important subjects for financial experts and researchers around the globe for several decades. The results of previous literature are mixed, for instance in favor of equity returns or the other way around. The debate on the effect of crude oil and gold prices on equity returns is also ongoing. Previous literature regarding the subject matter is rich and diversified, and all the important equity markets observed different effects at distinctive time periods and circumstances.

Literature: Oil prices and Equity prices

Business entities are the leading determinants of the economy if the business organizations perform well then the equity prices of these companies also increase. The organizational financial performance also depends on the crude oil prices; so, in this way, the price of crude oil has an indirect effect on equity prices of a particular firm and sector. According to Clare and Thomas (1994), the crude oil price shocks are major elements for the policy makers of a country. According to Basher and Sadorsky (2006) increase in oil prices increases in the rate of interest, which leads to an increase in inflation and the expense of doing business then eventually equity prices will decrease. Similarly, Park and Ratti (2008) examined fourteen countries and concluded a cogent negative association amidst the prices of crude oil and equity prices except for Norway (it is an oil exporting country). According to Faff and Brailsford (1999), there is a cogent effect of prices of crude oil on equity prices. Lee et al. (2012) had a significant research study on G7 countries and examined the effect of crude oil prices on composite indices. Outcomes of the research study revealed a significant impact of crude oil prices on the equity returns of these stock markets. However, that impact was varied sector-to-sector and country-to-country. The impact of crude oil prices shocks on the equity markets also depends on the nature of a country's position; the impact of oil prices is dissimilar for oil exporting and oil importing countries. The economy, which is the oil exporting country, the effect of oil prices has a cogent positive effect on the equity market; however, in a case of oil imports, the stock returns have a negative effect (Wang et al., 2013). Arouri et al. (2012) have examined the important equity markets of Europe and concluded a significant volatility spillover impact between equity prices and crude oil prices in the case of Europe.

Basher and Sadorsky (2006) have carried out an important study; they examined the impact of crude oil prices and the emerging markets and concluded that the declines in oil prices exerted a significant affirmative effect on equity prices of the emerging markets. Mardini and Ali (2016), Ghorbel and Souissi (2016) and Hu et al. (2016) have concluded the same positive association. According to Gisser and Goodwin (1986), Burbidge and Harrison (1984) and Darby (1982) there is an inverse association amidst crude oil prices and real activity for oil importing economies. Ansar and Asghar (2013) revealed a positive association among CPI, crude oil prices, and KSE100 returns. Abdalla et al. (2012) concluded that the fluctuations in crude oil price led to an increase in equity returns' volatility. Nandha and Faff (2008), Nejad et al. (2016), Miller and Ratti (2009), Broadstock et al. (2016), and Jones and Kaul (1996) also concluded an inverse association amidst crude oil prices and equity prices of emerging and developed stock indices of the world. According to Ramos and Veiga (2010), it is not necessary that decreases in the price of oil have a definite increase in equity prices. Previous research studies for instance Cunado and Perez de Garcia (2005), Bec and Gaye (2016), Kilian (2009), Albulescu et al. (2016), and Hamilton (1983, 2003) have concluded an affirmative and cogent causal association between crude oil prices, and specific economic indicators for instance inflation, GDP and equity returns of developed markets.

Literature: Gold prices and Stock returns

The gold price is also considered another important economic factor that measures the health and sustainability of the economy of a country. There is a common perception that gold price becomes bullish when the outlook of an economy downward and the financial market are found bearish, the policymakers struggle to instigate any exposition and there is uncertainty over future trends (Chen & Faff, 1998; Khan et al., 2016; Arouri et al., 2015; Wang et al., 2010). The other factors contribute to increasing the prices of gold include a weak currency, the increase in inflation rate, and decreases in interest rate in the long run. According to Raza et al. (2016) and Najaf et al. (2016) this a universal fact that gold prices and stock returns have an inverse relation. It is a known fact when gold prices decrease; investors move to equity markets for better returns. On the other hand, when an economy goes down, and equity markets turn towards negative then investors stepping in the metal markets in order to secure their investments (Azar, 2015; Nguyen et al., 2012). The Gold tends to be an asset in a physical form that provides hedging versus exchange rate, the rate of inflation, economic downturns and political uncertainty (Baur & Lucey, 2010; Capie et al., 2005; Mahdavi & Zhou, 1997; Worthington & Pahlavani, 2007). According to Soytas et al. (2009) there is an established correlation and volatility dynamics but associated with risk management hedge, but Coudert et al. (2007) concluded a negative or null affiliation amidst equity returns and gold prices in recessionary periods. According to Hillier et al. (2006), a week relationship existed between equity returns and gold returns that suggest gold prices can deliver divergent profits for equity portfolios. Baur and Lucey (2010) and Tully and Lucey (2005) established a constant time-varying association between gold returns and equity returns.

Wang et al. (2010) have examined the equity returns of stock indices of the China, Japan, the United States, and Germany, and gold prices. They established a long haul association amidst gold prices and equity returns except for the United States; they report the null association existed in the case of the US. According to Shahzadi and Chohan (2011), the relationship amidst equity prices of KSE100, and crude oil and gold prices found negative in case of Pakistan. Similarly, Kaliyamoorthy and Parithi (2012) have concluded a direct association amidst stock returns, and gold returns. Nguyen et al. (2012) investigated the impact of stock prices on the United States, the UK, Singapore, Thailand, Japan, Malaysia, Indonesia, and the Philippines, and the gold prices. They concluded an inverse association amidst the prices of gold and equity returns for most of the considered indices. According to Narang and Singh (2012) causal association amidst equity returns of the Indian markets and gold prices has not been established. According to Pritchard (2010) and Moore (1990) when equity markets decline than the price of gold increases, thus they concluded an inverse relationship between equity returns and gold returns. Lawrence (2003) concluded a weak association amidst equity returns and gold prices. However, that relationship behaves differently in the presence of other macroeconomic variables. Bhunia and Mukhuti (2013) investigated the association between equity returns of BSE and NSE and gold price; they concluded a null causal relationship between gold prices and equity returns. According to Baig et al. (2013), gold prices do not influence the KSE100 returns. Smith (2001) also concluded the same findings in the case of the United States.

Material and methods

Data collection

For this research study, the daily data of gold prices, crude oil prices, and KSE100 index have been acquired for the period from January 1, 2010, to June 30, 2016. For the similar selected time period, the data of prices of crude and gold prices have been downloaded from the Yahoo Finance website, and the data of KSE100 index is taken from the official website of Pakistan stock exchange.

Estimation techniques

The estimation techniques, we used for the undertaken research for instance correlation and descriptive analysis, Augmented Dickey-Fuller unit root test, Multivariate Johansen cointegration, ARCH and GARCH (1,1) econometric models, and Granger causality technique.

Returns of KSE100 index

From the Eq. (1) as follows, it is evident that we have taken the differences of natural log values for the calculation of KSE100 returns:

$$KSE100_{(t)} = \ln\left(C_t / C_{t-1}\right) \tag{1}$$

where: in Eq. (1) the term "KSE100 t" refers for the returns of KSE100 equity prices in "*t*" period of time, though, "*C t*" and "*C t*-1" are represented for the returns of equity prices of KSE100 of current daytime "*t*" and previous day period of time "*t*-1".

Returns of gold prices (GP)

From the Eq. (2) as follows, it is obvious that we have taken the differences of natural log values for the calculation of the returns of gold prices:

$$GP_{(t)} = \ln\left(GP_t / GP_{t-1}\right) \tag{2}$$

where: in Eq. (2) the term "*GP t*" refers for the returns of gold prices in "*t*" period of time, though, "*GP t*", and "*GP t*-1" represented for the returns of gold prices for the current daytime "*t*", and previous day period of time "*t*-1".

Returns of crude oil prices (COP)

From the Eq. (3) as follows, it is apparent that we have taken the differences of natural log values for the calculation of crude oil returns:

$$COP_{(t)} = \ln\left(COP_t / COP_{t-1}\right) \tag{3}$$

where: in Eq. (3) the term "*COP t*" mentions for the returns of crude oil prices in "*t*" period of time, though, "*COP t*", and "*COP t*-1" represented for the returns oil prices for the current daytime "*t*" and previous day period of time "*t*-1".

Augmented Dickey-Fuller testing approach

This is mandatory to transform time series data into stationary series to precede further analysis. Thus, the first objective to examine the unit root in the considered data series, therefore, we employed the Augmented Dickey-Fuller (1979, 1981) unit root test, which is an extensively used method worldwide. The mathematical form of the equation could be expressed as follows:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{i=1}^{n} \alpha \Delta y_t + e_t \tag{4}$$

where: in Eq. (4) the term 'y_t' represents for data time series in '*t*' time period, whereas, an optimal number of lags known as '*n*', and 'e_t' shows the white noise error in data time series, and the term '*α*' is considered as constant.

Johansen cointegration approach

It is generally; assume that if the affiliation of considered variables is stationary in a linear arrangement, then the taken variables are to be said cointegrated, though, it is not mandatory for a specific individual variable that has to be stationary. It is a possibility of long-haul equilibrium condition for integrating affiliation amongst the variables; however, in a short run, the variables are not dependent on each other. We have employed a time series model like Johansen multivariate cointegration approach to establishing the long haul association amongst the variables (Johansen, 1988, 1991; Johansen & Juselius, 1990). In Eq. (5) we incorporated '*n*' number of variables, which were non-stationary, and considered the VAR method with '*p*' lags. The equation could be written as follows:

$$\Delta y_t = \mu + \Delta_1 y_{t-1} + \dots\dots\dots\dots + \Delta_p y_{t-p} + \varepsilon_t \tag{5}$$

where: in Eq. (5) the term 'y_t' represented for (n_{x1}) vectors, however, 'ε_t' is known as the white noise error in the data time series. We have assimilated the variables in orders in Eq. (6), and then the mathematical expression could be written as follows:

$$\Delta y_t = \mu + \eta y_{t-1} + \sum_{i=1}^{n-1} \tau_t \Delta y_{t-1} + \varepsilon_t \tag{6}$$

where: in Eq. (6) $\eta = \sum_{i=1}^{p} \mathrm{A}_{i-1}$ and $\tau_t = \sum_{j=i+1}^{p} \mathrm{A}_j$

Johansen (1988, 1991, 1995), and Johansen and Juselius (1990) have developed the time series approach like multivariate Johansen cointegration. Thus, we have employed this approach to single out the values of cointegrating vectors. The aim of the exercise of this time series approach is to identify the two statistical tests, in which first test statistics is regarded as the *λ*-trace; this test statistics examines the void assumptions of considered time series. To investigate if the distinctive number of cointegrating vectors are equivalent to the '*p*' probability with respect to the unrestricted assortment *p* = *r*, thus the mathematical representation could be written as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_{r+1}\right) \tag{7}$$

where: in Eq. (7), the term '*T*' represents for operative clarifications numbers, and *λr* + 1 is recognized as the predictable Eigenvalues from the matrix. Though, the Eq. (8) is denoted for Maximum Eigenvalue, and can be expressed as follows:

$$\lambda_{\max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \tag{8}$$

where: the Eq. (8) examined the invalid suppositions whether there is '*r*' cointegrating vectors in relationship according to the theory of option, which signifies "*r* + 1" cointegrating vectors.

The Granger causality analysis

According to the time series approach, the Granger (1969) causality, it is essential to demonstrate and examine whether one variable can forecast another variable in different data time series. According to Goebel et al. (2003), this causality test is based on multiple linear regression techniques. Several research studies have been carried out on the basis of F-statistics residuals. According to Chen et al. (2009), the authorized trail coefficients can be used in order to execute T-test at group level statistics. MacFarlin et al. (2009) have explained the negative trail coefficients as an inhibitory outcome. Since we consider two data series "*X*" and "*Y*" then a pairwise test could be expressed as follows:

$$Y_t = \sum_{n=1}^{p} A_n X_{(t-p)} + \sum_{n=1}^{p} B_n Y_{(t-p)} + CZ_t + E_t \tag{9}$$

$$X_t = \sum_{n=1}^{p} A_n^{'} Y_{(t-p)}^{'} + \sum_{n=1}^{p} B_n^{'} X_{(t-p)}^{'} + C^{'} Z_t + E_t^{'} \tag{10}$$

where: in Eq. (9) & Eq. (10) '*X*' and '*Y*' denoted for two data series in the "*t*" period of time, if 'X_{t-p}' & 'Y_{t-p}' are known for these two data series for the time period "*t* - *p*" in "*p*" numbers of lagged time orders. If (A_n) & (A_n') represented for two authorized trailed measurements, and then (B_n) and (B_n') are called autoregression models, in which we take '*Zt*' as covariables at time period '*t*'.

The GARCH model

This method is used to evaluate the model volatility; this model has proposed by Bollerslev (1986) and termed as "Generalized Autoregressive Conditional Heteroskedasticity" or simply GARCH approach. This model is the up gradation of ARCH model. Since the ARCH model has the limitations to take the dynamic pattern in the case of conditional volatility, moreover, ARCH model cannot be used when the constraints are too large. Therefore, in order to avoid these limitations, we can use a GARCH model, in which conditional volatility is to be taken as a one-period future approximation for the variance. The conditional variance is depending on its own past lagged values, the most commonly used form of GARCH is known as the GARCH (1,1) model:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 \tag{11}$$

The interpretation of the Eq. (11) is that the existing tailored variance σ_t^2 is known as the function of long-term weighted average value, and it depends on α_0, tailored variance during the past first lag (α_0, σ_{t-1}^2), and volatility evidence during the past time (α, ε^2_{t-1}). Moreover, the coefficients should satisfy the condition of $\alpha_0 > 0$, $\alpha > 1$, and $\alpha_2 \geq 0$, in order of $\sigma_t^2 \geq 0$. If add lagged ε_t^2 on both sides of the Eq. (11) and moved σ_t^2 on the right side of the Eq. (11) then GARCH (1,1) could be written as ARMA (1,1) for squared errors:

$$\varepsilon_t^2 = \alpha_0 + \left(\alpha_1 + \beta_1\right)\varepsilon_{t-1}^2 + \left(\nu_t - \beta_1\right)\nu_{t-1} \tag{12}$$

where: in Eq. (12): $\nu_t = \varepsilon_t^2 - \sigma_t^2$

The GARCH (1,1) model is known to be the stationary in variance if the following condition will be met:

$$\alpha_1 + \beta_1 < 1$$

Therefore, in this case, the unconditional variance of 'ε_t' is to be considered a constant and then the expression can be expressed as:

$$\operatorname{var}\left(\varepsilon_t\right) = \frac{\alpha_0}{1-\left(\alpha_1+\beta_1\right)} \tag{13}$$

where: in Eq. (13) the variance is to be said a non-stationary when the unconditional variance of 'ε_t' is not expressed in the following case:

$$\alpha_1 + \beta_1 \geq 1$$

If the following condition persists then it means there is unit root in the variance, and as integrated GARCH or IGARCH:

$$\alpha_1 + \beta_1 = 1$$

Estimation and results

Descriptive analysis

According to the results of Table 1, it is evident that the average returns of KSE100 are 9.85 % with the volatility of 0.4676, which shows that the risk trade-off is the highest in a case of KSE100 returns. The returns of gold prices are also significant, i.e., 7.21 % with the least volatility of 0.1476. The reason for the low volatility of gold prices is because of the reason that the prices of gold remained stable during that period of time. Results of the Jarque-Bera test showed that data time series does not follow the normality; the probability is less than 0.05 in all the cases, which validate the results of non-normality of the series.

Tab. 1. Descriptive analysis.

Descriptive Statistics	LGP	LKSE100	LCOP
Mean	7.2114	9.8518	4.3482
Median	7.1748	9.8131	4.4842
Maximum	7.5436	10.5656	4.7356
Minimum	6.9573	9.1302	3.2661
Std. Dev.	0.1476	0.4676	0.3315
Skewness	0.3843	-0.0181	-1.2029
Kurtosis	4.9294	4.3950	6.2883
Jarque-Bera	117.02	173.65	395.56
Probability	0.00	0.00	0.00
Observations	1617	1617	1617

Correlation analysis

Table 2 shows the significant negative (-0.558) correlation between stock returns and gold returns in the considered sample period that demonstrated an inverse association amidst KSE100 returns and prices of gold. It is anticipated that if stocks return increase, then gold returns decrease or vice versa. It can be concluded that the investors are very much rationale to the downfall of any market. Thus, they switch their investments from respective markets whenever they experience any downfall in the economy. It is also noted a cogent but negative correlation (-0.564) amidst crude oil prices, and equity prices, which shows a long run business activities felt decline due to the indirect effect of inflation because of oil price increases, and subsequently that also hampers the share values of the companies. Finally, correlation analysis shows a significant positive relation (0.568) amidst crude oil and gold prices as shown in Table 2.

Tab. 2. Correlation analysis.

Variables		KSE100 index	Gold Prices	Crude oil Prices
KSE100 index	Pearson Correlation	1	-.558**	-.564**
	Sig. (2-tailed)		.000	.000
	N	1617	1617	1617
Gold Prices	Pearson Correlation	-.558**	1	.568**
	Sig. (2-tailed)	.000		.000
	N	1617	1617	1617
Crude Oil Prices	Pearson Correlation	-.564**	.568**	1
	Sig. (2-tailed)	.000	.000	
	N	1617	1617	1617

Homoscedasticity Tests (Inferential Statistics)

For inferential analysis and to identify the homoscedasticity in data series, we employed Bartlett's (1937), Levene's and Brown-Forsythe tests. The results of the tests exhibited that considered data series followed the pattern of non-normality. The p-value is less than 0.05 for all three tests. Therefore, it is concluded that there is no homoscedasticity among the variables and data series, and our taken three variables have shown a non-normality pattern as well (Table 3).

Tab. 3. Inferential analysis.

Method	Df		Value	Probability
Bartlett	2		1797.86	0.0000
Levene	(2, 4848)		1503.85	0.0000
Brown-Forsythe	(2, 4848)		1051.00	0.0000
Category Statistics				
Variable	Count	Std. Dev.	Mean Diff.	Median Diff.
LKSE100	1617	0.4676	0.4326	0.4321
LGP	1617	0.1476	0.1267	0.1231
LCOP	1617	0.3315	0.2670	0.2389
All	4851	2.273487	0.275435	0.264704
Bartlett weighted standard deviation: 0.341714				

Stationary and non-stationary graphs

The first column of Figure 1 shows the trends observed by stock returns, gold prices, and oil prices over the time period. This is also evident from the following graphs of Figure 1; the stock returns have inclination trend throughout the time period. On the contrary, the series of gold and crude oil prices observed a positive trend and later turns into a negative trend, which depicted for the presence of unit roots. In order to formally investigate unit roots, we employed unit root test (ADF) in the next section. The left-hand side of Figure 1 exhibited the series are non-stationary at level; however, the second column of Figure 1 displayed a stationary pattern at first difference.

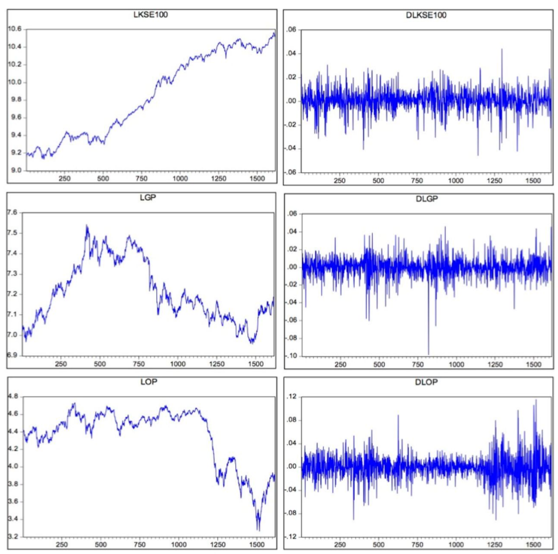

Fig. 1. Stationary and non-stationary Series.

Augmented Dickey-Fuller (ADF) techniques

Outcomes of Table 4 demonstrated that all the data series for instance returns of KSE100, crude oil prices, and gold prices have unit root at level; therefore, we used Augmented Dickey-Fuller approach, and check the unit root. The outcomes of Table 4 exhibited that the data series are non-stationary at the level, however, at first difference data series transformed into stationary form.

Tab. 4. Augmented Dickey-Fuller stationarity test.

Variables	Augmented Dickey-Fuller test statistic				Test critical values		
	At Level		At 1st Difference		1% level	5% level	10% level
	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	t-Statistic	t-Statistic
LGP	-1.8057	0.3780	-41.2722	0.0000	-3.4318	-2.8621	-2.5671
LCOP	-0.8884	0.7923	-41.7273	0.0000	-3.4318	-2.8621	-2.5671
LKSE100	-0.3841	0.9094	-36.1019	0.0000	-3.4318	-2.8621	-2.5671

**MacKinnon (1996) one-sided p-values.*

VAR Lag Order Selection Criteria

Since we have already investigated the orders of integration or the data series are transformed into stationary for equity returns of KSE100, crude oil, and gold prices. The next step is to identify the appropriate lags length before employing cointegration approach. We employed lag length criteria of selection that follows the Akaike (1973) information criterion (AIC), which demonstrated lags 0 and lags 1 for considered data time series as exhibited in Table 5.

Tab. 5. VAR lag order criteria: DLKSE100 DLGP DLCOP.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	14169.83	NA	0.00	-17.62	-17.61*	-17.61
1	14188.61	37.47	4.41e-12*	-17.63260*	-17.59	-17.61769*
2	14194.12	10.98	0.00	-17.63	-17.56	-17.60
3	14203.95	19.52	0.00	-17.63	-17.53	-17.59
4	14211.04	14.07	0.00	-17.63	-17.50	-17.58
5	14222.09	21.89*	0.00	-17.63	-17.47	-17.57
6	14226.45	8.61	0.00	-17.62	-17.43	-17.55
7	14234.70	16.28	0.00	-17.62	-17.40	-17.54
8	14238.64	7.76	0.00	-17.62	-17.37	-17.52

** denotes lag order selection criterion*
AIC: Akaike information criterion

Multivariate Johansen cointegration for LKSE100, LGP, and LCOP

Since ADF test demonstrated that the KSE100 returns, crude oil and gold prices data series are stationary at first difference. Thus, the Johansen multivariate cointegration technique could be employed. In order to find a lag length of LKSE100, LCOP, and LGP, we used the Akaike information criteria to determine the appropriate lags, i.e. 0 and 1 as identified in the previous section. Outcomes of Table 6 demonstrated that there is no evidence of cointegrating vectors amongst the data series; hence, we have established that there is no long haul association amidst equity returns of KSE100 and crude oil and gold prices in the considered time period. This conclusion further substantiated by the values of trace and maximum Eigen tests because of both trace statistics and Max-Eigen statistics < Critical value, and corresponding probabilities are also higher than 0.05.

Tab. 6. Cointegration test for LKSE100, LCOP & LGP.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. Of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None*	0.0065	17.0387	29.7971	0.6372
At most 1	0.0036	6.5059	15.4947	0.6357
At most 2	0.0004	0.6932	3.8415	0.4051
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		**Max-Eigen**	**0.05**	
No. Of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None*	0.0065	10.5328	21.1316	0.6936
At most 1	0.0036	5.8127	14.2646	0.6374
At most 2	0.0004	0.6932	3.8415	0.4051

Max & Trace tests show no traces of cointegration vector at 0.05 levels
** Indicates rejection of the null hypothesis at 0.05 level*
*** MacKinnon-Haug-Mitchelis (1999)-p-value*

Granger causality test results

For the identification of causality and direction between the pair of variables, we employed the pairwise test of Granger causality. We have selected Lag 1 and lag 2 to know the better understanding of the causality. The results of Table 7 exhibited the unidirectional causality between DLKSE100 and DLCOP from crude oil prices to KSE100 index in lag 1 and Lag 2 at 5% level. However, unidirectional causality existed between DLKSE100 and DLCOP does not mean to carry change in other variables. Basically, in time series causality is unavoidable for the drive of variables (Awe, 2012).

Tab. 7. Results of Pairwise Granger Causality

Lags: 1			
Null Hypothesis:	**Obs.**	**F-Statistic**	**Prob.**
DLGP does not Granger cause DLKSE100	1615	0.9415	0.3320
DLKSE100 does not Granger cause DLGP		0.1797	0.6717
DLOP does not Granger cause DLKSE100	1615	13.3069	0.0003
DLKSE100 does not Granger cause DLCOP		0.4700	0.4931
DLOP does not Granger cause DLGP	1615	0.0479	0.8268
DLGP does not Granger cause DLCOP		0.0069	0.9340

Lags: 2			
Null Hypothesis:	**Obs.**	**F-Statistic**	**Prob.**
DLGP does not Granger cause DLKSE100	1614	1.1386	0.3205
DLKSE100 does not Granger cause DLGP		0.0666	0.9355
DLOP does not Granger cause DLKSE100	1614	7.1274	0.0008
DLKSE100 does not Granger cause DLCOP		0.1920	0.8254
DLOP does not Granger cause DLGP	1614	0.2012	0.8178
DLGP does not Granger cause DLCOP		2.3859	0.0923

Conditional Volatilities

Figure 2 exhibited that both patterns of time series confirmed the volatility-grouping occurrence, which indicates that significant variation leads to other massive changes, and small variations tend to follow minor variations. This hallmark indicates the possible spillover effects in returns and volatility among the stock returns, oil prices changes, and changes in gold prices. Hence, in this situation, GARCH type models are the preferred choice of methodology for these kinds of data time series (Francq & Zakoïan, 2010). Therefore, it is observed from Figure 2 both series behave like the same ways suggesting GARCH (1,1) instead of a higher order of ARCH in all three series.

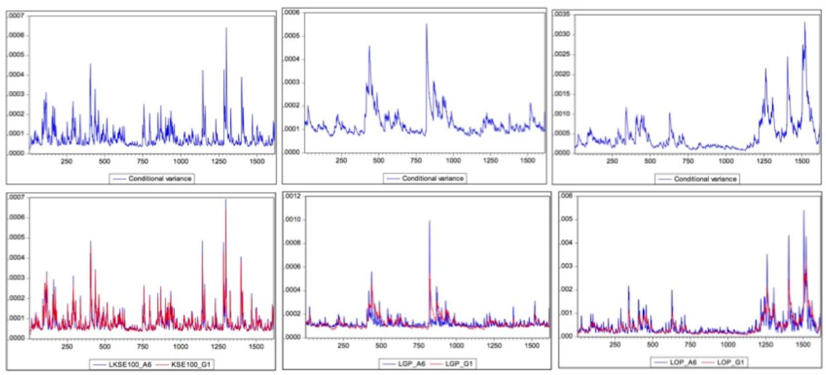

Fig. 2. Conditional Volatilities in both series

Testing for Heteroscedasticity in residual (ARCH-LM test)

Conditional heteroscedasticity in residual is the pre-condition for using the GARCH (1,1) model. Therefore, we employed ARCH-LM test to check the conditional heteroscedasticity in residuals. Engle (1982) has developed ARCH-LM test; according to the results of Table 8, there are no traces of heteroscedasticity in residuals for all the time series ($F>4$ & $p<0.05$). It is further demonstrated from the results that there is significant evidence of ARCH effects for all time series at lags 3 and lags 6. This suggested that the GARCH type model is the preferred choice in order to investigate the spillover of the volatility amidst equity returns, and gold and crude oil prices.

Tab. 8. Testing for Heteroscedasticity (ARCH-LM test.

LKSE100 Series (for Lag 3 & Lag 6)			
F-statistic	11.89494	Prob. F(3,1608)	0.0000
Obs*R-squared	34.99694	Prob. Chi-Square (3)	0.0000
F-statistic	7.966101	Prob. F(6,1602)	0.0000
Obs*R-squared	46.61468	Prob. Chi-Square (6)	0.0000
LGP Series (for Lag 3 & Lag 6)			
F-statistic	11.558174	Prob. F(3,1608)	0.0198
Obs*R-squared	34.672568	Prob. Chi-Square (3)	0.0074
F-statistic	10.908028	Prob. F(6,1602)	0.0062
Obs*R-squared	11.4166	Prob. Chi-Square (6)	0.0263
LCOP Series (for Lag 3 & Lag 6)			
F-statistic	30.27119	Prob. F(3,1608)	0.0000
Obs*R-squared	86.17277	Prob. Chi-Square (3)	0.0000
F-statistic	17.65408	Prob. F(6,1602)	0.0000
Obs*R-squared	99.78922	Prob. Chi-Square (6)	0.0000

Testing for Heteroscedasticity in residuals (White Test)

White (1980) test is the next step to validate the heteroscedasticity in residuals; according to the results of Table 9, there are no traces of heteroscedasticity in residuals because probabilities are less than 0.05. According to the results, it is indicated that ARCH is not present at lag 1; however, presented at lags 3 and lags 6 suggesting GARCH (1,1) is an appropriate model for LKSE100, LGP, and LCOP series.

Tab. 9. White Test-Dependent variable: WGT_RESID^2.

LKSE100 Series (for Lag 3 & Lag 6)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
WGT_RESID^2(-3)	0.0830	0.0249	3.3358	0.0009
WGT_RESID^2(-6)	0.0647	0.0251	2.5808	0.0099
LGP Series (for Lag 3 & Lag 6)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
WGT_RESID^2(-3)	0.0275	0.0247	2.1035	0.0270
WGT_RESID^2(-6)	0.0387	0.0253	2.5274	0.0127
LCOP Series (for Lag 3 & Lag 6)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
WGT_RESID^2(-3)	0.1641	0.0246	6.6703	0.0000
WGT_RESID^2(-6)	0.0798	0.0252	3.1676	0.0016

The GARCH (1,1) Analysis

The GARCH (1,1) test has been applied after checking for heteroskedasticity. Table 10 exhibits the results of GARCH (1,1) approach in terms of variance and means equations, in which we used a maximum likelihood technique. Table 10 showed the different diagnostic parameters, the results of mean equation depicted that DLCOP influences the stock to mean returns ($p < 0.05$), however, there is no influence of DLGP on the returns of equities as exhibited by the Panel A in Table 10. Results of the ARCH and GARCH evaluate the conditional variances of macroeconomic variables such as gold price, and oil price. An outcome of the GARCH (1,1) approach shows the influence of equity returns' shocks on prevailing volatility die out with the passage of time. The coefficients α and β established a short run dynamics of the subsequent volatility data series.

Outcomes of Panel-B in Table 10 showed that three parameters of the variance equation namely the intercept (C), the squared returns of the first lag ARCH (α). However, the GARCH (β) is referred for the first lag of conditional variance. Both coefficient ARCH (α) and GARCH (β) are affirmative that indicate a lag of squared returns and lagged conditional variance exerted a cogent effect on conditional variance. It is further established that ARCH and GARCH effects have significant positive effects on stock returns. However, both ARCH and GARCH effects have evidence of volatility on KSE100 returns; this elaborates that there is a volatility grouping in Pakistan stock exchange. The positive values of ARCH and GARCH effects are in line with the previous literature (Engle, 1982; Bollerslev, 1986).

Tab. 10. Results of the GARCH (1,1) approach.

The Panel A: the mean equation				
Variable	**Coefficient**	**Std. Error**	**Z-Statistic**	**Prob.**
C	0.1690	0.1095	1.7159	0.2101
DLGP	0.0559	0.0592	2.5438	0.0156
DLCOP	0.1563	0.0277	5.6393	0.0000
The Panel B: the variance equation				
C	0.0000	0.0000	3.0695	0.0021
ARCH (α)	0.0847	0.0111	7.6058	0.0000
GARCH (β)	0.9092	0.0114	80.0741	0.0000
R-squared	0.0008	Mean dependent var.		-0.0003
Adjusted R-squared	0.0002	S.D. dependent var.		0.0211
S.E. of regression	0.0211	Akaike info criterion		-5.1621
Sum squared resid	0.7164	Schwarz criterion		-5.1454
Log-likelihood	4173.40	Hannan-Quinn criter.		-5.1559
Durbin-Watson stat	2.05	$\alpha + \beta < 1$		0.9938

Results of Table 10 also exhibited the long-term perseverance because the summation of parameters ARCH (α), and GARCH (β) is lower than one that indicates a long memory process. It is further observed from the sum of coefficients ($\alpha + \beta < 1$) that demonstrated an unconditional variance is stationary, and there is a mean-reverting variance process. A high value of $\alpha + \beta$, thus, it implies a 'long memory', which is again a property of the return series used in this study as the value of $\alpha + \beta$ in the GARCH estimation is very close to one (Walter, 2014; Carter et al., 2008). Since the coefficient α is significantly lower than the β coefficient that demonstrates that past volatility affects the volatility of KSE100 index and large β demonstrates that the shocks of volatility to the conditional variance take a longer period to die out.

Discussion

The undertaken research study examines the relationships amidst KSE100 equity returns and variation in oil and gold prices. The descriptive analysis showed significant stock returns with high volatility. Correlation analysis showed a significant negative relationship between equity returns, and crude oil and gold prices. The results of our study are very much consistent with the outcomes of previous literature such as (Azar, 2015; Nguyen et al., 2012; Shahzadi & Chohan, 2011; Pritchard, 2010; Moore, 1990; Sadorsky, 2004). Outcomes of Johansen multivariate cointegration approach exhibited no long haul association amidst equity returns of KSE100, and crude oil and gold prices. Similarly, previous studies also concluded the same results ((Raza et al., 2016; Najaf et al., 2016; Nguyen et al., 2012; Pritchard, 2010; Baur & Lucey, 2010). Results of Granger causality indicated a unidirectional causality from crude oil prices to equity returns in Lags 1 and 2. These results are also inclined with previous literature (Bhunia & Mukhuti, 2013; Kaliyamoorthy & Parithi, 2012). The results of GATCH (1,1) estimates showed that crude prices affect the volatility of stock returns of KSE100 index. Hence, GARCH (1,1) results are also in line with the previous literature such as (Raza et al., 2016; Khan et al., 2016; Najaf et al., 2016; Toraman et al., 2011; Topcu, 2010; Ghosh et al., 2004).

Conclusion

The correlation showed an inverse association between equity prices and gold prices, this confirmed the postulates if stocks return increase then gold returns decrease or vice versa. It can be concluded that the investors are very much rationale to the downfall of any market. Thus they switch their investments from respective markets whenever they experience any downfall. It is also concluded a cogent but negative correlation amidst equity returns and oil prices, which explains the long run business activities experienced a decline due to the indirect effect of inflation because of oil price increases, and subsequently, that also hampers the share values of the companies. The returns of the KSE100 index are significantly higher but with higher volatility as compared to the gold returns. It is further concluded from the results of this research that there is a short-run association between equity returns, and oil and crude prices, but did not conclude any long-haul relationship amongst the variables. It is also concluded that the unidirectional causality existed between equity prices and oil prices, the direction of this causality is from oil prices to equity returns in lags 1 and 2. The GARCH (1,1) also confirmed the Granger causality results and demonstrated that there is a cogent and positive impact of oil prices on equity returns of KSE100. Hence, it is finally concluded that because of an oil importing country, the oil prices have a significant impact on equity prices of KSE100 index and long-haul sustainability on the Pakistani economy.

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