Avazkhodjaev, Salokhiddin; Mukhamedov, Farkhod; Usmonov, Jaloliddin

Article

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Do Energy and Gold Markets Interact with Islamic Stocks? Evidence from the Asia-Pacific Markets

Salokhiddin Avazkhodjaev[1,2]*, Farkhod Mukhamedov[2], Jaloliddin Usmonov[3]

[1]Graduate School of Business, Universiti Kebangsaan Malaysia, Bangi, Malaysia, [2]Faculty of Finance, Tashkent Institute of Finance, Tashkent, Uzbekistan, [3]Binary University of Management & Entrepreneurship, Puchong, Malaysia. *Email: xalqaro@tfi.uz

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ABSTRACT

This paper examines the influence of Islamic stock price uncertainty on energy and gold commodity prices by using daily data from September 25, 2014 to March 12, 2021. We employ the MGARCH-M model with DCC and BEKK approaches to assess interrelationship selected series. Based on empirical estimations, we achieved the following results. Firstly, empirical results from MGARCH–M model estimations Islamic stock price uncertainty have a significant positive effect on energy and gold commodities price. Secondly, non-causality tests results bared bi-directional variance transmissions of Islamic stock prices and the conditional variations of energy and gold commodities prices. Finally, for the pre-pandemic periods, results of the GIRF analaysis provided that the innovation shocks of Islamic stock price returns have a negative effects on energy and gold price uncertainty. Indeed, for the response of ongoing pandemic periods shows Islamic stock price returns have a negative interact on commodities price volatility, except energy stock price.

Keywords: Energy, Gold and DJ Islamic Stock Prices, MGARCH-M, Volatility Modelling
JEL Classifications: G01, G15, Q012

1. INTRODUCTION

In the process of globalization, the emergence of Islamic finance as an effective direction of financial relations has led to a growing interest in their unique potential. The share of Islamic finance in the international financial system is growing steadily, reaching a total annual value of $ 2 trillion (Paltrinieri et al., 2019). It is known that the world community is feeling the consequences of the recent economic, financial and social crisis. For example, the 1998 Asian financial crisis, the global financial and economic slumps that began in 2008 after the Great Depression, and the ongoing COVID-19 pandemic have prompted many researchers and academics have to pay more attention to the interdependence of commodity and Islamic stock markets. (Bahloul and Khemakhem, 2021; Hachicha et al., 2021; Salisu et al., 2020; Abdullahi, 2021; Alkhazalia and Zoubib, 2020; Boubaker and Rezgui, 2020). The problems in the aforementioned periods of recession are considered important for the following reasons. Firstly, the global financial and economic crisis and the debt crisis in Europe have exacerbated the link between equity returns in many countries around the world. This process reflects the spread of financial fluctuations in across different countries. Consequently, it is important to investigate the impact of Islamic stock price uncertainty on commodity markets during the ongoing pandemic crisis around the world. Indeed, examining changes in the interdependence of the stock market and commodity markets underlines the effectiveness of international diversification for potential investors, especially in Islamic stock markets.

Moreover, the selected commodity markets are plays an important role in the Islamic financial market, as the world's major energy and gold producers follow the Islamic faith, thereby sharing their risk to each other particularly during the financial downturns. The ongoing pandemic crisis is increasingly arousing the interest of international investors in secondary risks in the Islamic financial markets during the period of social slumps. It should be noted that even before the ongoing pandemic, i.e. since January 2020, a significant increase in commodity prices revived the discussion about the role of individual commodities in the process of asset allocation by companies. In this regard, the investigation of the relationship between the commodity and stock markets is especially relevant at a time when the attention of investors is focused on the optimal investment climate in a pandemic.

Indeed, the causal relationship between Islamic securities and the prices of primary or secondary commodities is also of particular importance to potential investors and markets, especially those interested in faith-based investments. It is known that the uncertainty of upward or downward commodity prices has a significant impact not only on Islamic securities, but also on the hedging strategy that international investors are constantly promoting. While the focus of all previous empirical studies on energy and gold markets has been limited to the convetional stock markets, studies on Islamic stock markets has evolved over the last 3 years. For instance, For example, few studies in recent years have examined economic fluctuations and their relationship to the stock market. (Jones and Olson, 2013, for the US market; Chang et al., 2015, for OECD countries and Christou et al., 2017, for markets from Pacific – Rim). In addition, other empirical studies investigated the nexus between returns of stock markets and energy, also commodities prices (Sadorsky, 1999; Choi and Hammoudeh, 2010; Salisu and Oloko, 2015), while other researchers examined the influence of investor sentiment on stock and commodity markets (Wang et al., 2013; Aloui et al., 2018; Bekiros et al., 2016; Perez-Liston et al., 2016; Dash and Maitra, 2017; Hasanov and Avazkhodjaev, 2022; Shakhabiddinovich et.al., 2022).

In the case of Islamic securities markets, limited empirical studies to the causal relationship among commodities (gold and energy market), and Islamic stock markets obtained which reflected mixed results. Indeed, Bahloul and Khemakhem (2021) achieved that commodity indices showed the upward sources of shocks to the Islamic stock markets. Using the Windowed Scalogram Difference and Wavelet Coherence approaches, Boubaker and Rezgui (2020) investigated that investors in the Islamic stock markets do not rely on the prices of commodities are gold, oil and gas. Likewise, Using the wavelet analysis to Islamic stock index and Energy and Precious Metal indices Khan and Masih (2021) investigated how Islamic and commodities markets commoved from the period of 2008–2012 which is global financial crisis began in the USA.

This paper generally differs from the other studies in two ways. Firstly, despite the fact of necessity, a limited number of empirical studies seem to have focused on uncertainty effects among both Islamic stock and energy and gold markets, for the period of pre-and ongoing-pandemic. Finally, a methodological approach adopted in this paper relies on advances in the field of financial modeling and empirical finance. Especially, we apply the MGARCH-M model suggested by Bauwens et al. (2006) to assess effects of Islamic stock price uncertainty on commodities stock price. Moreover, we employ a none-derivative simplex method to obtain initial guesses for quasi-maximum likelihood method. Also, we applied mean non–causality tests developed by Hafner and Herwartz (2008) among the prices of Islamic stock and the gold and energy markets, which is achieved by estimating parameters for variance-covariance matrix specifications (BEKK) proposed by Engle and Kroner (1995) and dynamic conditional correlation (DCC) structure developed Engle (2002). Finally, we also employ GIRF - generalized impulse response function analysis to inspect the response of gold and energy prices to Islamic stock price uncertainty.

The remainder of this paper is structured as follows. Section 2 discusses a brief review of the literature, and Sections 3 and 4 show data and empirical methods. Section 5 reports empirical results and discussion. Lastly, Section 6 provides concluding remarks and policy implications.

2. LITERATURE REVIEW

Looking at recent empirical research on the post global financial crisis and debt crisis in Europe, some empirical researchs have focused on the Islamic financial markets and their interdependence on commodity markets. Privious empirical literatures documented that the causal nexus between Islamic stocks and commodity markets. For example, Khan and Masih (2014) investigated the relationship between commodities and Islamic equities vary over time and are highly volatile. Using the MGARCH-DCC and Wavelet Coherence approaches, Nagayev et al. (2016) studied that the causal nexus between commodity markets and the Dow Jones Islamic market index are time varying. Similarly, Mensi et al. (2017) study results showed that Islamic financial markets among energy and gold, technology sectors were found as a receiver of risk spillovers. Authors was employ spillover index provided from Diebold and Yilmaz (2014) to determine the dynamic interconnectedness among DJ Islamic stock market, oil (crude) and gold markets.

New empirical literatures provide evidence of the uncertainty affects among gold, energy and Islamic stock markets. For example, Bahloul and Khemakhem (2021) examined on the interconnectedness among emerging countries Islamic stock market uncertainty and variabilities of commodity market indices under estimations of the Diebold and Yilmaz (2014) interconnectedness index based on VAR approach. They suggested that commodity markets showed the high volatility of shocks to the Islamic stock market for the selected period. Using a rolling-window procedure with, GARCH family models with DCC and ADCC specifications Hachicha et al. (2021) examined the conventional and DJ Islamic stock markets, the optimal hedging with gold and crude oil, also selected emerging countries' sectoral indices (health care, raw materials and telecommunication industries. The authors concluded selected sectoral indices were found the best-hedged instruments for the conventional and Islamic portfolios, also they showed the highest hedged effectiveness.

Furthermore, using the Windowed Scalogram Difference (WSD) Boubaker and Rezgui (2020) examined the co-movements of selected commodities are gold, crude oil, gas and the DJ Islamic stock market indices was applied with daily data. Author's findings that potential investors for the Islamic financial markets did not base their decisions on gold, oil and gas stock prices. Indeed, Mishra et al. (2019) analysed the interrelationship between the variability of DJ Islamic stock market and global crude oil prices for the daily period of 01/1996 to 04/2018. The study results indicate that volatility of crude oil prices may have a positive effect on Islamic stock index in short-run, but on achieving sustainable, the oil prices have a negative impact on the Islamic stock market. Using the wavelet analysis Khan and Masih (2021) investigated commodity (Energy and Precious Metal) markets and their connectedness between Islamic stock markets for the period of the Global financial crisis. Authors found that the co-movement among Energy and DJ Islamic markets is significantly more compared to the co-movement with the Precious Metal sector at different time scales and fluctuations. Erdogan et al. (2020) examined interrelationships of uncertainty effects among Islamic stock and exchange markets the case of Turkey, Malaysia, India. The authors employed variance non-causality analysis for variability effects. Estimation results showed that, evidence of uncertainty effects from Islamic financial markets to the exchange market only for the Turkey. Results of time-varying test provided the results show that the availability of uncertainty is at least one line between exchange rate risk and, the Islamic financial markets for the selected periods.

Using stochastic dominance approach Alkhazalia and Zoubib (2020) studied the role of diversification of DJ Islamic stock portfolios to gold market. The authors achieved that portfolios of gold and Islamic stock one stochastically dominated without gold at in Islamic stock indices. In addition, they found the SD order is appear under the 2007-2009 global financial crisis period in all ownership holdings of gold. Authors concluded that potential investors may have design related investments with gold for the purpose on diversification of Islamic stock portfolios.

Despite these studies, which have determined the nexus among commodities and Islamic stock markets, these studies are is still in the process of development under the ongoing pandemic crisis. In sum, keeping view the limitation of the recent empirical literature, particularly on Islamic financial markets, using multivariate MGARCH-M models this paper investigated the interrelationship among DJ Islamic stock, gold, and energy price indices. Finally, we also determined whether asymmetric models perform better than symmetric models.

3. DATA AND PRELIMINARY STATISTICS

We to the base on the three extensively used Islamic stock, energy and gold commodity indices in Asia-Pacific financial and commodity markets. Firstly, we used the Asia-Pacific DJ Islamic Stock Market Index. Secondly, we chose the DJ Commodity Gold and Energy Indices. The daily periods for selected three indices as on ended March 12, 2021, and commenced on September 25, 2014. We got the data on selected Islamic stock and commodity price indices from the www.investing.com database. All data was represented in US Dollar in order to have same dataset. Figure 1 presents the evolution of returns and daily prices for the DJ Islamic stock and gold and energy price indices. A broad review of the graphs shows that the DJ Islamic stock index experienced relatively low inconvenient returns in the pandemic periods than most of the Asia-Pacific stock markets.

Table 1 represents the preliminary statistics for Islamic stock price, energy, and gold commodity indices for the whole sample period. The daily stock and commodity indices returns have structured as the first differences of the natural logarithm, $R_{i,t}$, as follows

$$R_{i,t} = \ln\left(\frac{K_i}{K_{i,t-1}}\right) \times 100$$

where subscript i denotes Islamic stock index ($K_{s,t}$), gold price ($K_{g,t}$), and energy price ($K_{e,t}$), respectively. According to the table entries, the averages of daily returns are smaller than their computed standard deviations in all cases.

It was observed that the Islamic stock mean return is positive and more than the mean return of commodity (gold and energy) indices under study. In addition, we observed the standard deviation of Islamic stock returns is less than the standard deviation of return for commodities indices. This implies that Islamic stock is more profitable and less risky than commodities such as gold and energy over the selected sample periods. The kurtosis and skewness of the price returns of the Islamic stock and commodities indices are significant. The return was negative for all selected indices by skewness. The negative skewness implies that the returns were not distributed normally. Jarque-Bera statistics confirmed nor normality returns in selected stock indices. Finally, for the sample size eloborated in the study, the variables seem to be conditionally heteroskedastic. Therefore, MGARCH-M model emerges to be appropriate in empirical estimation.

In Table 2, the Ljung–Box Q test statistics of Ljung and Box (1978) for serial correlation of the return series and the squared returns series of $K_{s,t}$, $K_{g,t}$, and $K_{e,t}$ are thoroughly detailed. In sum, the all tests reject the null hypothesis of the existence of unit root at one percent significance level, and thus the returns follow a stationary process regardless of whether a trend variable or/and incorporated in the model.

4. EMPIRICAL METHODOLOGY

The main prupose of the paper was to investigate the volatility effects of Islamic stock price on energy and gold prices employing the contemporary single-step procedure. Using the multivariate GARCH-in-mean model with the single-step approach for time series properties of the series under study. With this regards, the paper follows to Grier and Perry, 2004; Grier and Smallwood, 2013, and VAR–MGARCH-M–BEKK and VAR–MGARCH–M–DCC econometric approaches will be jointly employed in model estimation. Model measurements rely on various BEKK specifications proposed by Engle and Kroner (1995) and DCC structure developed Engle (2002) to achieve most robust results. The next objective was to examine the non-causality between the Islamic stock and commodies (energy and gold) price. Finally, we exploit generalized impulse response function analysis among variables, vice versa.

Figure 1: Evolution of DJ Islamic stock market and commodities indices for daily prices and returns

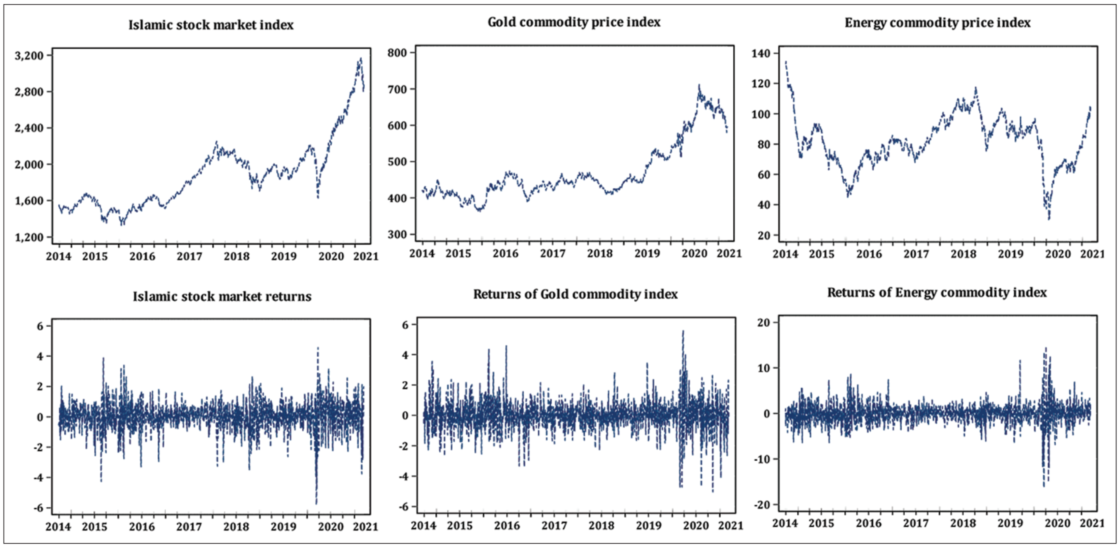


Table 1: Descriptive statistics for daily prices of Islamic stock, gold and energy

Series	$K_{s,t}$	$K_{g,t}$	$K_{e,t}$
Mean	0.0368	0.0203	−0.0143
Median	0.0673	0.0188	0.0523
Maximum	4.5694	5.6001	460.49
Minimum	−5.8014	−5.0556	−460.60
St. Deviation	0.8831	0.9163	16.041
Skewness	−0.4798	−0.0260	−0.0117
Kurtosis	7.0190	8.0129	806.96
Jarque-Bera	1199.4***	1765.5***	4540.7***

Significance level *, **, *** indicated 10%, 5% and 1%, respectively. Here, $K_{s,t}$, $K_{g,t}$, and $K_{e,t}$ denote log changes for prices of Islamic stock, gold and energy, respectively

Table 2: Serial correlation, ARCH and unit root tests

Series	$K_{s,t}$	$K_{g,t}$	$K_{e,t}$
Q (4)	24.644***	6.3138	406.31***
Q (8)	29.482***	11.078	406.32***
BDS (8)	0.0503***	0.0186***	0.0579***
ARCH (4)	58.598***	17.834***	278.48***
ADF(μ)	−24.908***	−38.059***	−18.438***
ADF(τ)	−25.475***	−41.413***	−20.052***
PP(μ)	−37.106***	−41.467***	−166.05***
PP(τ)	−38.167***	−41.481***	−178.20***
KPSS(μ)	0.3151	0.8332	0.2133
KPSS(τ)	0.0600	0.0434	0.0869
No. obs	1686	1686	1686

Significance level *, **, *** indicated 10%, 5% and 1%, respectively. Here, $K_{s,t}$, $K_{g,t}$, and $K_{e,t}$ denote log changes for prices of Islamic stock, gold and energy, respectively

4.1. Multivariate GARCH-in-mean Model

It is obvious that the assessing of MGARCH–M model of Bollerslev et al. (1988) with Vector Autoregression framework of Sims (1980) has become one of the empirical generality in macroeconomic variability and uncertainty related research works (Elder, 2004). As mentioned in above context, Engle and Kroner (1995) have provided some theoretical and comceptual frameworks related to generating MGARCH–M and the recent empirical works which are based on them (Grier and Perry, 1998; Grier and Perry, 2000). It seems to works that the exploitation of MGARCH–M model which is jointly with p^{th} orders structural Vector Autoregression depends on the dynamic interactions between the selected variables. Based on this context, the general equation of the study is detailed as follows

$$Y_t = M + \sum_{i=1}^{p} \Gamma^{(i)} Y_{t-1} + \Psi H_t + U_t \qquad (1)$$

$$U_t | \Omega_{t-1} \sim N(0, H_t)$$

where, Y_t is $n\times1$ dimensional matrix of dependent variable, and M is $n\times1$ dimensional matrix that denotes the coefficient of constant in the equation. $\Gamma^{(i)}$ (i=1.,p) is $n\times n$ dimensional matrix that presented the slope coefficients of the lagged form for dependent variables, Y_{t-1}. Ψ presented a polynomial matrix. H_t (t=1.,T) is an asymmetric conditional BEKK specification. Noted that H_t was assumed as a diagonal that the structural errors were serially not correlated. In turn, U_t is stochastic error terms of the main equation and it is normally distributed with all t. Ω_{t-1} is the available set of information at the time t–1, and H_t is explained through the asymmetric BEKK approach. In below, the dependent and explanatory variables as well as other coefficients of the model in order to explain clearly are expressed in matrix form.

In Eq. (1), the Ψ matrix of uncertainty parameter is also incorporate to analysis the uncertainty effects of Islamic stock market on the conditional variations of commodities are gold and energy prices.

$$\begin{bmatrix} s_t \\ g_t \\ e_t \end{bmatrix} = \begin{bmatrix} \mu_s \\ \mu_g \\ \mu_e \end{bmatrix} + \begin{bmatrix} \gamma_{11}^{(i)} & \gamma_{12}^{(i)} & \gamma_{13}^{(i)} \\ \gamma_{21}^{(i)} & \gamma_{22}^{(i)} & \gamma_{23}^{(i)} \\ \gamma_{31}^{(i)} & \gamma_{32}^{(i)} & \gamma_{33}^{(i)} \end{bmatrix} \begin{bmatrix} r_{t-i} \\ x_{t-i} \\ f_{t-i} \end{bmatrix} + \begin{bmatrix} \psi_{11} & \psi_{12} & \psi_{13} \\ \psi_{21} & \psi_{22} & \psi_{23} \\ \psi_{31} & \psi_{32} & \psi_{33} \end{bmatrix} \begin{bmatrix} h_{11,t} \\ h_{22,t} \\ h_{33,t} \end{bmatrix} \begin{bmatrix} u_{s,t} \\ u_{g,t} \\ u_{e,t} \end{bmatrix} \qquad (2)$$

from Eq. (3), the equations can be draw as follows:

$$\begin{cases} s_t = \mu_s + \gamma_{11}^{(i)} s_{t-i} + \gamma_{12}^{(i)} g_{t-i} + \gamma_{13}^{(i)} e_{t-i} + \psi_{11} h_{11,t} + \psi_{12} h_{22,t} \\ +\psi_{13} h_{33,t} + u_{s,t} \\ g_t = \mu_g + \gamma_{21}^{(i)} s_{t-i} + \gamma_{22}^{(i)} g_{t-i} + \gamma_{23}^{(i)} e_{t-i} + \psi_{21} h_{11,t} + \psi_{22} h_{22,t} \\ +\psi_{23} h_{33,t} + u_{g,t} \\ e_t = \mu_e + \gamma_{31}^{(i)} s_{t-i} + \gamma_{32}^{(i)} g_{t-i} + \gamma_{33}^{(i)} e_{t-i} + \psi_{31} h_{11,t} + \psi_{32} h_{22,t} \\ +\psi_{33} h_{33,t} + u_{e,t} \end{cases} \quad (3)$$

In Eq. 3, the independent variable s_t denotes Islamic stock market returns, while s_{t-i}, are lagged forms of it (i=1.,n). μ_s is the coefficient of intercept, and $\gamma_{11}^{(i)}, \gamma_{12}^{(i)}, \gamma_{13}^{(i)}$ specify the slope coefficients of the equation (i=1.,n). ψ_{13} is denoted the coefficient of interest that indicates the volatility impact of Islamic stock market in frequent fluctuations of gold and energy price series. Furthermore, h_{33} is denoted the influence of energy and gold price uncertainty on Islamic stock changes.

4.2. Asymmetric BEKK Variance–covariance structure

As aforementioned, this paper attempts to estimate Islamic stock, gold and energy equations jointly by exploiting VAR–MGARCH–M–BEKK and also VAR–MGARCH–M–DCC (see. section 4.3) econometric approaches, and it included the asymmetric, and non–diagonality in the conditional BEKK specification. The advantage of asymmetric BEKK approach is that the conditional variance–covariance process makes sure about the positivity of parameters. Here, an overview of the structure for the study is specified as follows:

$$H_t = C^{'}C + A^{'}u_{t-1}u_{t-1}^{'}A + B^{'}H_{t-1}B + D^{'}\zeta_{t-1}\zeta_{t-1}^{'}D \quad (4)$$

In below, the cubic form of asymmetric BEKK approach is given to confirm the positive definiteness of the variance-covariance process.

$$H_t = \begin{bmatrix} h_{s,t}^2 & h_{s,g,t} & h_{s,e,t} \\ h_{g,s,t} & h_{g,t}^2 & h_{g,e,t} \\ h_{e,s,t} & h_{e,g,t} & h_{e,t}^2 \end{bmatrix} = \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix}^{'} \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix}$$

$$+ \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}^{'} \begin{bmatrix} u_{t-1} \\ u_{t-1} \\ u_{t-1} \end{bmatrix} \begin{bmatrix} u_{t-1} \\ u_{t-1} \\ u_{t-1} \end{bmatrix}^{'} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$+ \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}^{'} \begin{bmatrix} h_{s,t-1}^2 & h_{s,g,t-1} & h_{s,e,t-1} \\ h_{g,s,t-1} & h_{g,t-1}^2 & h_{g,e,t-1} \\ h_{e,s,t-1} & h_{e,g,t-1} & h_{e,t-1}^2 \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$$

$$+ \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix}^{'} \begin{bmatrix} \zeta_{t-1} \\ \zeta_{t-1} \\ \zeta_{t-1} \end{bmatrix} \begin{bmatrix} \zeta_{t-1} \\ \zeta_{t-1} \\ \zeta_{t-1} \end{bmatrix}^{'} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \quad (5)$$

Eq. (5) is the conditional BEKK appoach with the absolute form that contains asymmetry and non–diagonality. Besides, it considers lagged conditional variances and co-variances, H_{t-1}, as well as lagged form of u_{t-1} u_{t-1}' and ζ_{t-1} ζ_{t-1}', in joint estimations of Islamic stock market uncertainty on the conditional variations of commodities (gold and energy).

4.3. Asymmetric Dynamic Conditional Correlation (DCC)

We used a DCC - dynamic conditional correlation approach proposed by Engle (2002). The main characteristic of the DCC approach is flexibility in allowing idiosyncratic choices for the conditional variance of each residual sequence. Here we applied of the following mention.

Let Y_t denoted the 3×1 vector containing Islamic stock price return (Δs_t), gold (Δg_t), and energy (Δe_t) prices. For an $N \times N$ matrix A, diagonal (A) denotes the vector that results from stacking the diagonal elements of A, while diagonal (A) denotes the matrix that results from setting the off-diagonal elements of A to zero. Diagonal ($A^{-1/2}$) is equivalent to diagonal (A), where the corresponding diagonal elements are equal to the inverse of the square roots of the diagonal elements of A. In sum, with Ω_t denting the information set a time t, with M denoting a 3×1 vector of constants, $\Gamma^{(i)}$ and $A^{(i)}$ are denotes 3×3 matrices of coefficients capturing the effects of lagged values of Y_t and lagged values of the conditional standard deviations, Y_t is modeled as follow,

$$Y_t = M + \sum_{i=1}^{p} “_{(i)} Y_{t-j} + \mathrm{A}_{(i)} diag\left(D_{t-i}\right) + u_t \quad (6)$$

where,

$$u_t | \Omega_{t-1} \sim N(0, H_t) \quad (7)$$

$$H_t = D_t R_t D_t, \ \varepsilon_t = D_t^{-1} u_t \quad (8)$$

$$A_i = \begin{bmatrix} 0 & \lambda_{g,h_{e^*e^*}}^{(i)} & \lambda_{g,h_i}^{(i)} \\ 0 & 0 & 0 \\ 0 & 0 & \lambda_{s,h_i^{(i)}} \end{bmatrix}, \quad A_t = \begin{bmatrix} h_{ss,t}^{1/2} & 0 & 0 \\ 0 & h_{gg,t}^{1/2} & 0 \\ 0 & 0 & h_{e^*e^*,t}^{1/2} \end{bmatrix} \quad (9)$$

$$h_{ss,t} = K_i + \alpha_i u_{i.t-1}^2 + \delta_i h_{ss.t-1} + \tau_i \mathrm{I}_{\{u_{i.t-1}<0\}} u_{i.t-1}^2, \quad i = s, g, e^* \quad (10)$$

Finally, we define the parameters the correlation matrix using the auxiliary matrix Q_t as follows:

$$Q_t = \left(1 - a - b\right) R + a\varepsilon_{t-1}\varepsilon_{t-1}^{'} + bQ_{t-1} \quad (11)$$

where R denotes the unconditional correlation matrix, and where taking expectations of (12)

$$E\left(Q_t\right) = \frac{\left(1-a-b\right)R}{1-b} + \frac{aED_{t-1}^{-1}U_{t-1}U_{t-1}^{'}D_{t-1}^{-1}}{1-bL} \quad (12)$$

$$= \frac{\left(1-a-b\right)R}{1-b} + \frac{aR}{1-b} = R \quad (13)$$

In sum, to ensure that a correlation matrix results we emphasize R_t as follows:

$$R_t = DgQ_t^{-1/2} \ Q_t \ Dg\ (Q_t)^{-1/2} \quad (14)$$

We count the same time all of the model parameters in (6)–(14) using numerical maximum likelihood. Here, let θ denotes the full set of equation parameters for both the mean equations and for the MGARCH-M-DCC approach. With N=3 and based on a sample of size T, our unrestricted objective function becomes.

$$L_U\left(\theta;Y_t\right)=-\frac{1}{2}\sum_{t=1}^{T}\left(Nlog2\pi+logdetH_t+U_t^{'}H_t^{-1}U_t\right) \quad (15)$$

Finally, instead of evaluating the mean and standard deviation parameters separately, the parameters of this study were evaluated simultaneously.

4.4. Non–causality Test

Regarding the one of the objective of the paper, we employ non–causality test of Hafner and Herwartz (2008), which is attin by estimating parameters for BEKK approach of Engle and Kroner (1995). We bare two conditionally heteroskedastic and stationary series such as $Y_{1,t}$, $Y_{2,t}$ and $Y_{3,t}$ for Y=s,g and e where we indicate the return series of Islamic stock price, gold and energy stock prices, respectively. Here, we consider that $Y_{2,t}$ and $Y_{3,t}$ doesn't Granger cause $Y_{1,t}$ in variance, designated by $Y_{2,t}$ and $Y_{3,t} \nrightarrow Y_{1,t}$ if,

$$Var(Y_{1,t}|F_{t-1})=Var(Y_{1,t}|F_{t-1})|\forall t\in Z \quad (16)$$

Eq. (16) outlines any causality relationships; if $Y_{1,t}$ does Granger cause $Y_{2,t}$ and $Y_{3,t}$ in variance, the conditional variance of $Y_{2,t}$ and $Y_{3,t}$ can be predicted more accurate by dimention the information set of $Y_{1,t}$. Here, the null hypothesis of Granger causality from the Islamic stock market uncertainty (i) on gold price variability (g) in the second moment equation of the economies under concern is stated as follows

$$H_0\text{: } a_{12}=b_{12}=0 \quad (17)$$

By the same token, the null hypothesis of the Granger causality from the Islamic stock market volatility (i) to energy price variability (e) of the respective economies is also specified as follows

$$H_0\text{: } a_{13}=b_{13}=0 \quad (18)$$

To test these hypotheses, following to the provided approach by Hafner and Herwartz (2008), the standard Wald-test statistics are proposed as follows

$$W_t=T(Qa)'\,(Q\Sigma_{\vartheta}\,Q')^{-1}\,(Q1) \quad (19)$$

where Q=[0,Q,Q], ϑ= ($vech$ (C)',$vech$ (A)',$vech$ (B)')', Σ_{ϑ}=E[u_t u_t']<∞ and asymptotic chi-square (χ^2) distribution has a degree of freedom that equal to the number of limited parameters of the statistic, as given by

$$W_t \rightarrow \chi^2_{k(K-k)} \quad (20)$$

In sum by this section, we employ Wald test statistics to carry out non–causality test on estimated model of the paper.

4.5. Generalized Impulses Response Function Analysis (GIRF)

To examine the time mode of the effects of Islamic stock price shocks on future behavior of gold and energy price uncertainty, we employ the GIRF proposed by Koop et al. (1996). We created an analytical framework of impulse responses of Islamic stock price returns to one unit of gold and energy price uncertainty under the VAR process. Following to Grier et al. (2004), the shock effects of Islamic stock price volatiltity on gold and energy price variability are marked through the conditional mean and with a lag through the second moment equation. As given in Grier et al. (2004) the GIRF of the paper is detailed as follows:

$$GIRF_K\;(\mathrm{n},\varrho_t,\omega_{t-1})=E[K_{t+n}|\varrho_t,\omega_{t-1}-E[K_{t+n}|\omega_{t-1}] \quad (21)$$

where n = 0,1,2,3..., thus the GIRF is conditional on ϱ_t and ω_{t-1} and constructed the responses by average future shocks given in the previous and present. Giving it, a natural reference point for GIRF is the conditional expectation of K_{t+n} given only the history ω_{t-1}, and in this shock response the current shock is also averaged out.

5. EMPIRICAL RESULTS AND DISCUSSION

In this section, the empirical results from model estimation is detailed discussed. A mentioned above in introduction section, our main pirpose was to investigate volatiltity effects between Islamic stock stock price and two commodities sector (gold and energy) indices. We employed test of non-causality between series under concern. Finally, we conducted the generalized impulse response function analysis for Islamic stock price uncertainty to a one unit of gold and energy price volatility of the respective Asia-Pacific stock market under the VAR process.

5.1. Estimation Results of VAR–MGARCH–M–BEKK Model

In Table 3, the results for estimated mean equations of Islamic stock, gold and energy prices for the Asia-Pacific market are reported. Here, μ_s, μ_g and μ_e are the coefficient of intercept that carry the negative values Islamic stock and energy price equations and indicates the negative values for the gold pirce equation. Moreover, we consider matrices $\Gamma^{(i)}$ (i=1,2,3) for Islamic stock, gold and energy price return, which are used in the mean equations and captured by the parameters $\gamma_{k,j}^{(i)}$ to realize the relationship across the return and price series of under concern. While, the diagonal parameters of $\gamma_{k,j}^{(i)}, k=j, \gamma_{s,s}^{(1)}, \gamma_{s,s}^{(2)}, \gamma_{g,g}^{(2)}, \gamma_{g,g}^{(3)} \quad \gamma_{e,e}^{(1)}, \gamma_{e,e}^{(3)}$ for the selected return and price series are statistically significant.

It should be noted that the cross variable logarithmic change links among the variables under concern and it can be examined by the off-diagonal elements, and the results are noteworthy. Indeed, the off-diagonal parameters $\gamma_{s,e}^{(1)}, \gamma_{s,g}^{(2)}, \gamma_{s,e}^{(2)}, \gamma_{s,e}^{(3)}, \gamma_{g,e}^{(2)}, \gamma_{g,e}^{(3)}, \gamma_{e,s}^{(2)}, \gamma_{e,g}^{(2)}$ for the variables under study, are statistically significant. Supplementary, their counterparts are statistically insignifancant.

As mentioned above, the main objectives of the paper was to determine the causal nexus between Islamic stock and commodities prices, it can be concluded from the sign and significance of $\Psi_{s,g}$ and $\Psi_{s,e}$ that the point estimates of these selected stock and commodities series are equal to 0.1791 and 0.0228, respectively. As a result, the based on model estimation, the conditional standard deviation of Islamic stock price uncertainty has a significant positive impacts on gold and energy prices.

Table 3: Parameter estimates for VAR (p)-MGARCH-M-BEKK model

s_t		g_t		e_t	
Mean specification					
μ_s	–0.1420**	μ_g	0.0253	μ_e	–0.0425
$\gamma_{s,s}^{(1)}$	0.0758***	$\gamma_{g,s}^{(1)}$	0.0140	$\gamma_{e,s}^{(1)}$	0.0392
$\gamma_{s,g}^{(1)}$	0.0284	$\gamma_{g,g}^{(1)}$	–0.0262	$\gamma_{e,g}^{(1)}$	–0.0409
$\gamma_{s,e}^{(1)}$	0.0186***	$\gamma_{g,e}^{(1)}$	0.0087	$\gamma_{e,e}^{(1)}$	–0.0150*
$\gamma_{s,i}^{(2)}$	0.0151*	$\gamma_{g,s}^{(2)}$	0.0158	$\gamma_{e,s}^{(2)}$	0.1025**
$\gamma_{s,g}^{(2)}$	0.0362**	$\gamma_{g,g}^{(2)}$	0.0076*	$\gamma_{e,g}^{(2)}$	0.0668*
$\gamma_{s,e}^{(2)}$	0.0054**	$\gamma_{g,e}^{(2)}$	0.0033**	$\gamma_{e,e}^{(2)}$	0.0096
$\gamma_{s,i}^{(3)}$	–0.0100	$\gamma_{g,s}^{(3)}$	0.0214	$\gamma_{e,s}^{(3)}$	0.0363
$\gamma_{s,g}^{(3)}$	0.0289	$\gamma_{g,g}^{(3)}$	0.0197*	$\gamma_{e,g}^{(3)}$	0.0138
$\gamma_{s,e}^{(3)}$	0.0021**	$\gamma_{g,e}^{(3)}$	0.0015**	$\gamma_{e,e}^{(3)}$	0.0266*
$\Psi_{s,s}$	0.0098	$\Psi_{g,s}$	–0.0620**	$\Psi_{e,s}$	–0.1025
$\Psi_{s,g}$	0.1791***	$\Psi_{g,g}$	0.0072	$\Psi_{e,g}$	–0.1771**
$\Psi_{s,e}$	0.0228***	$\Psi_{g,e}$	0.0131**	$\Psi_{e,e}$	0.1468***
Shape	4.8509***	AIC	8.935	HQC	9.022
LL	–7445.4	SBC	9.170	FPE	8.935
Variance-covariance specification					
$c_{1,1}$	0.1607***	$c_{1,2}$	—	$c_{1,3}$	—
$c_{2,1}$	–0.0491**	$c_{2,2}$	0.0284	$c_{2,3}$	—
$c_{3,1}$	–0.6109	$c_{3,2}$	–0.7012***	$c_{3,3}$	1.1395***
$a_{1,1}$	0.0498*	$a_{1,2}$	–0.0228	$a_{1,3}$	–0.0454
$a_{2,1}$	–0.0523	$a_{2,2}$	0.1124***	$a_{2,3}$	–0.4643***
$a_{3,1}$	0.0164***	$a_{3,2}$	0.0081**	$a_{3,3}$	0.5756***
$b_{1,1}$	0.9362***	$b_{1,2}$	0.0047*	$b_{1,3}$	0.3229*
$b_{2,1}$	0.0226***	$b_{2,2}$	0.9906***	$b_{2,3}$	0.0512*
$b_{3,1}$	–0.0147***	$b_{3,2}$	–0.0079*	$b_{3,3}$	0.4172***
$d_{1,1}$	0.4562***	$d_{1,2}$	0.0009	$d_{1,3}$	0.0574
$d_{2,1}$	–0.1849***	$d_{2,2}$	0.0512*	$d_{2,3}$	0.2360
$d_{3,1}$	–0.0086***	$d_{3,2}$	0.0001	$d_{3,3}$	0.0526*

Significance level *, **, *** indicated 10%, 5% and 1%, respectively. AIC, SBC, HQC and FPE are acronyms for the Akaike information criterion, Schwarz Bayesian criterion, Hannan-Quinn criterion and Final prediction errors, respectively. LL stands for log-likelihood value

Moreover, in Table 3, further informs that estimated parameters of matrices C,A,B*,* and D which are detailed in the conditional second moment equation. In the equation, the diagonal elements of matrix A, a_{11}, a_{22} and a_{33} capture own ARCH effects, while the off-diagonal elements a_{12}, a_{21}, a_{13}, a_{31} and a_{23}, a_{32} evaluate the effects of shock to Islamic stock lagged return on the contemporaneous gold and energy price of the Asia-Pacific stock and commodity markets under concern. Referring on the table entries, a set of results are worth mentioning. Firstly, the statistical significant coefficient a_{11}, a_{22} and a_{33} for Asia-Pacific stock and commodity markets imply that the volatilities of Islamic stock price returna and energy, and gold prices were affected by the shocks from their own returns, except a_{12}, a_{21} respectively. Secondly, we found an evidence of bi-directional shock transmissions among the uncertainty of Islamic stock price returns and commodities (gold and enegy) prices.

Indeed, similar to the interpretation of the elements of matrix *A,* the diagonal elements, b_{11}, b_{22} and b_{33} in matrix *B*, capture own GARCH effects, while off-diagonal elements, b_{12}, b_{21}, b_{13}, b_{31} and b_{23}, b_{32} measure the effects of lagged variability of Islamic stok and commodies price series under study. Since the diagonal elements of the matrix *B*, b_{11}, b_{22} and b_{33} generally express a strong GARCH(1,1) process, which drives from the conditional standard deviations, all these statistical elements for the respective selected series under study shows the highly heteroscedasticity in residual terms of the employed model. Moreover, we found the bi-directional adverse uncertainty spillover effect from the Islamic stock price volatility to gold and energy price variability. Likewise, this is due to fact that the point estimate all off-diagonal elementes for the respective Islamic stock and commodity prices were statistically significant.

Furthermore, the asymmetric parameter matrix *D* is concerned, there is evidence of an asymmetric response to positive shocks for returns, as a diagonal parameters $d_{11,}$ d_{22} and d_{33} are statistically insignificant of the respective markets under concern. The statistically significant off-diagonal elements of the matrix *D*, specially $d_{21,}$ d_{31} respectively. In sum, the Islamic stock price variablity of them responses asymmetrically towards to the shocks of gold and energy price volatility of the respective Asia-Pacific Islamic stock and commodiy markets.

5.2. Estimation Results for VAR–MGARCH–M–DCC Model

The primary purpose of this section was to report of empirical analysis between selected Islamic stock and commodity markets

Table 4: Parameter estimates for VAR (p)-MGARCH-M-DCC model

s_t		g_t		e_t	
Mean specification					
μ_s	–0.1892**	μ_g	0.0343	μ_e	–0.1247**
$\gamma_{s,s}^{(1)}$	0.0832***	$\gamma_{g,s}^{(1)}$	0.0213	$\gamma_{e,s}^{(1)}$	0.0270
$\gamma_{s,g}^{(1)}$	0.0394**	$\gamma_{g,g}^{(1)}$	–0.0361*	$\gamma_{e,g}^{(1)}$	–0.0412
$\gamma_{s,e}^{(1)}$	0.0017***	$\gamma_{g,e}^{(1)}$	0.0004	$\gamma_{e,e}^{(1)}$	–0.0275
$\gamma_{s,s}^{(2)}$	0.0297	$\gamma_{g,s}^{(2)}$	0.0135	$\gamma_{e,s}^{(2)}$	0.1157
$\gamma_{s,g}^{(2)}$	0.0342*	$\gamma_{g,g}^{(2)}$	0.0073	$\gamma_{e,g}^{(2)}$	0.0689
$\gamma_{s,e}^{(2)}$	–0.0006**	$\gamma_{g,e}^{(2)}$	0.0002	$\gamma_{e,e}^{(2)}$	–0.0029
$\Psi_{s,s}$	0.0755***	$\Psi_{g,s}$	–0.0637**	$\Psi_{e,s}$	0.0234
$\Psi_{s,g}$	0.2152**	$\Psi_{g,g}$	0.0303	$\Psi_{e,g}$	0.0852
$\Psi_{s,e}$	0.0039***	$\Psi_{g,e}$	0.0009	$\Psi_{e,e}$	0.0327
Shape	4.8331***	AIC	8.938	HQC	8.992
LL	–7481.0	SBC	9.083	FPE	8.938
Dynamic conditional correlation					
c_1	0.0389**	c_2	0.0055	c_3	1.5604***
a_1	–0.0010*	a_2	0.0208*	a_3	0.2553***
b_1	0.8644***	b_2	0.9746***	b_3	0.3924***
d_1	0.1717**	d_2	0.0051*	d_3	0.0890*
DCC_A	0.0078***	DCC_B	0.9910***	-	

Significance level *, **, *** indicated 10%, 5% and 1%, respectively. AIC, SBC, HQC and FPE are acronyms for the Akaike information criterion, Schwarz Bayesian criterion, Hannan-Quinn criterion and Final prediction errors, respectively. LL stands for log-likelihood value

and their determinants by utilizing the dynamic conditional correlation (DCC) model proposed by Engle (2002). In Table 4, the results for estimated mean equations of Islamic stock and commodities are gold and energy prices, for Asia-Pacific stock and commodity markets under investigation are reported. Here, μ_s, μ_g and μ_e are the coefficient of intercept that carry the positive effect Islamic stock and energy prices, and indicate the negative value for the gold price intercept of the equations. In this analysis consider matrices $\Gamma^{(i)}$ (i=1,2) for selected stock and commodity markets, which is used in the mean equations and captured by the parameters $\gamma_{k,j}^{(i)}$ to realize the relationship across the return and price series under study.

Moreover, in Table 4, the diagonal parameters of $\gamma_{s,s}^{(1)}$ is statistically significant, However, other the diagonal parameters are statistically insignificant. Also, the off-diagonal parameteres for s_t equation statistically significant. Other counterpart equations' off-diagonal parameteres are statistically insignificant. The significance of $\Psi_{s,g}$ and $\Psi_{s,e}$ that the point estimates of markets is equal to 0.2152 and 0.0039. The statistical significant coefficient of a_1, a_2 and a_3 for the Islamic and commodity markets imply that the volatilities of Islamic stock market and commodity prices are gold and energy of respective markets are affected by the shocks from their own returns, respectively. Furthermore, the elements of matrix *A,* the elements, b_1, b_2 and b_3 in matrix *B*, capture own GARCH effects. Since the elements of the matrix *B*, b_1, b_2 and b_3 generally express a strong GARCH(1,1) process, which drives from the conditional standard deviations, all these statistical elements for the respective markets showing the highly heteroscedasticity in residual terms of the employed model. Finally, the evidence of an asymmetric response (asymmetric parameter matrix D) to positive shocks for return series, as a parameters d_1, d_2 and d_3, also DCC(A) and DCC(B) are statistically significant of the respective Islamic stock and commodity markets.

5.3. Robustness Checks and Model Specification Tests

The entries of Table 5, present the results for robustness checks: Univariate and multivariate tests for the standardized residuals of Islamic stock ($z_{s,t}$), gold ($z_{g,t}$), and energy ($z_{e,t}$) price equations for the respective Asia-Pacific stock and commodities market. In addition, the results of the diversity test show that there are no inconsistencies in the standard errors, as well as many other cases and other studies. The tests' statistics with null hypotheses are reported in Tables 5 and 6, they are noteworthy. First, relying on preliminary data analysis, there is significant conditional heteroscedasticity in the series under study. It can be also confirmed that the parameter matrices A, B and D provide the jointly statistically significant parameter estimates. As given in Table 6, all the entries of the elements of parameter matrices are jointly significant, and express well–specified second moment equation. Second, the jointly statistical significant off–diagonal elements of these parameter matrices express that the lagged conditional variances in Islamic stock price uncertainty have an impact on commodities prices are gold and energy. So, the joint significance of the elements of parameter matrix D clarifies that the specified conditional second moment equation is asymmetric.

Based on model estimations, the asymmetric responses are spotted for the specified model on the causal nexus between Islamic stock price volatility and commodities (gold and energy) prices of the Asia-Pacific stock and commodity markets. Moreover, the significance of a_{11} and d_{11} shows evidence of variance asymmetry in Islamic stock market. Likewise, the significance of a_{22}, d_{22} and a_{33}, d_{33} also displays the response of own variance asymmetry in commodities prices, and it implies

Table 5: Results of univariate and multivariate tests

	Univariate	$Z_{s,t}$	$Z_{g,t}$	$Z_{e,t}$	Multivariate	Statistic
			MGARCH-M-BEKK			
Asia-Pacific	Ljung-Box Q (8)	3.3264	4.2306	0.0814	Multivariate Q (8)	x^2 (72)=31.378
	Mc-Leod-Li (8)	4.0811	22.209**	0.0050		
	ARCH LM (8)	0.522	2.381	0.001		
			MGARCH-M-DCC			
Asia-Pacific	Ljung-Box Q (8)	2.2819	6.1126	0.0836	M Multivariate Q (8)	x^2 (72)=29.164
	Mc-Leod-Li (8)	5.2994	14.196**	0.0050		
	ARCH LM (8)	0.696	1.630	0.001		

***, **, *Indicate 1%, 5% and 10% significance level, respectively. Here, $Z_{i,t}$, $Z_{g,t}$ and $Z_{e,t}$ denote log changes for prices of Islamic stock, gold and energy, respectively

Table 6: Specification tests of multivariate GARCH-in-mean model

Specification tests			
		MGARCH-M-BEKK	
Asia-Pacific	Diagonal VAR	$H_0: \gamma_{12}^{(i)} = \gamma_{21}^{(i)} = \gamma_{13}^{(i)} = \gamma_{31}^{(i)} = \gamma_{23}^{(i)} = \gamma_{32}^{(i)} = 0, i = 1,2,3$	χ^2 (6) = 6.7822***
	Diagonal GARCH	$H_0: a_{ij} = b_{ij} = d_{ij} = 0$, if i≠j; i, j=1,2,3	χ^2 (18) = 54.080***
	No GARCH	H_0: $a_{ij} = b_{ij} = d_{ij} = 0$, for all i, j=1,2,3	χ^2 (27) = 101470.6***
	No GARCH-M	H_0: $\Psi_{ij} = 0$, for all i, j=1,2,3	χ^2 (6) = 8.1549***
	No Asymmetry	H_0: $d_{ij} = 0$, for all i, j=1,2,3	χ^2 (9) = 18024.0***
		MGARCH-M-DCC	
Asia-Pacific	Diagonal VAR	$H_0: \gamma_{12}^{(i)} = \gamma_{21}^{(i)} = \gamma_{13}^{(i)} = \gamma_{31}^{(i)} = \gamma_{23}^{(i)} = \gamma_{32}^{(i)} = 0, i = 1,2$	χ^2 (3) = 11.195***
	No GARCH	H_0: $a_{ij} = b_{ij} = d_{ij} = 0$, for all *i, j*=1,2,3	χ^2 (9) = 7964.6***
	No GARCH-M	H_0: $\Psi_{ij} = 0$, for all *i, j*=1,2,3	χ^2 (9) = 83.994***
	No Asymmetry	H_0: $d_{ij} = 0$, for all *i, j*=1,2,3	χ^2 (3) = 12.835***

Significance level *, **, *** indicated 10%, 5% and 1%, respectively

Table 7: Wald test statistics: non-causality test results

Market	Series	s_t↓	g_t↓	e_t↓	Result
Asia-Pacific	i_t→	2980.0***	0.8604**	1.7413**	Bi-directional
	g_t→	4.8765***	104157.5***	9.5978***	Bi-directional
	e_t→	8.5124***	3.3097**	146.65***	Bi-directional

Significance level *, **, *** indicated 10%, 5% and 1%, respectively, The sign→and↓denote causative in the derection of the arrows

that positive gold and energy shocks on based under estimation M-GARCH-M-BEKK model.

Figure 2 illustrates visual inspections that Asia-Pacific Islamic stock and commodity markets produced a strong performance in Islamic stock market volatiltity dynamics and that the conditional standard deviation was high volatile for the pandemic period Q1 of 2020's, reaching the highest level in Q2 and Q3 of 2020. In a fact, uncertainty performances of gold price series display exceedingly frequent fluctuations over the period Q1 and Q2, 2020, but estimated standard deviations are quite low (below 5 percent). Initially, Energy price variability trend gradually increased and grasped it's the highest level (around more than 100 percent) in Q2 and Q3, 2020.

5.4. Results of Non-causality Test

As mentioned in section 4, we apply Wald test statistics proposed by Hafner and Herwartz (2008) to carry out non-causality analysis on estimated model. Table 7 presents non–causality test results in conditional variances, and they follow the asymptotic Chi–squared (χ^2) distribution with a degree of freedom that is unrestricted in parameter estimation.

Referring to the table entries, there are a bi-directional variance transmissions Islamic stock and the conditional variations of commodities are gold and energy for respective Asia-Pacific Islamic stock and commodity markets.

5.5. Results of Generalized Impulse Response Function Analysis

As mentioned earlier, we exploit in section of empirical models that the analytical framework of the GIRF of Isamic stock returns to one standard deviation shocks of gold price uncertainty and energy price volatility under the vector autoregression process of the respective stock and commodity markets under concern are illustrated in Figure 3. We used GIRF analysis for daily sample periods for all three Islamic stock and commodity indices to start on December 01, 2018, for the proxy pre-pandemic periods. The impulses responses to a unit of shock innovations for the ongoing-pandemic periods starts on January 01, 2020, respectively.

Referring to Figure 3, the solid black redline is the response to a unit of shock innovations, while the dashed lines are the confidence intervals; each unit time horizon denotes a daily series. The results in Figure 3, Panel (a) suggest that the innovation shocks of Asia-Pacific DJ Islamic stock market returns has a negative impact on gold and energy price uncertainty.

Prior to the effect of the shock, the Islamic stock returns have an immediate response of approximately - 0.1% or −0.2%, respectively. The GIRF grows after the shock effect in Asia-Pacific stock and commodities markets and reaches −0.2 and −0.1 percent point of the initial unit shock within 80–120 days; this effects takes around 150 days for fully dissipate in pre-pandemic sample periods. While, the innovation shocks of commodities are gold and

Figure 2: Time path of the estimated conditional variances of DJ Islamic stock price and commodities indices returns

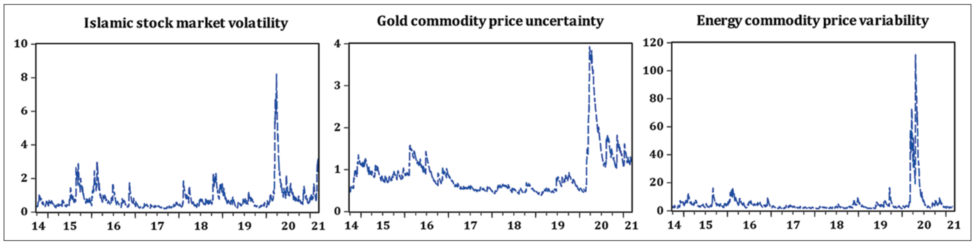
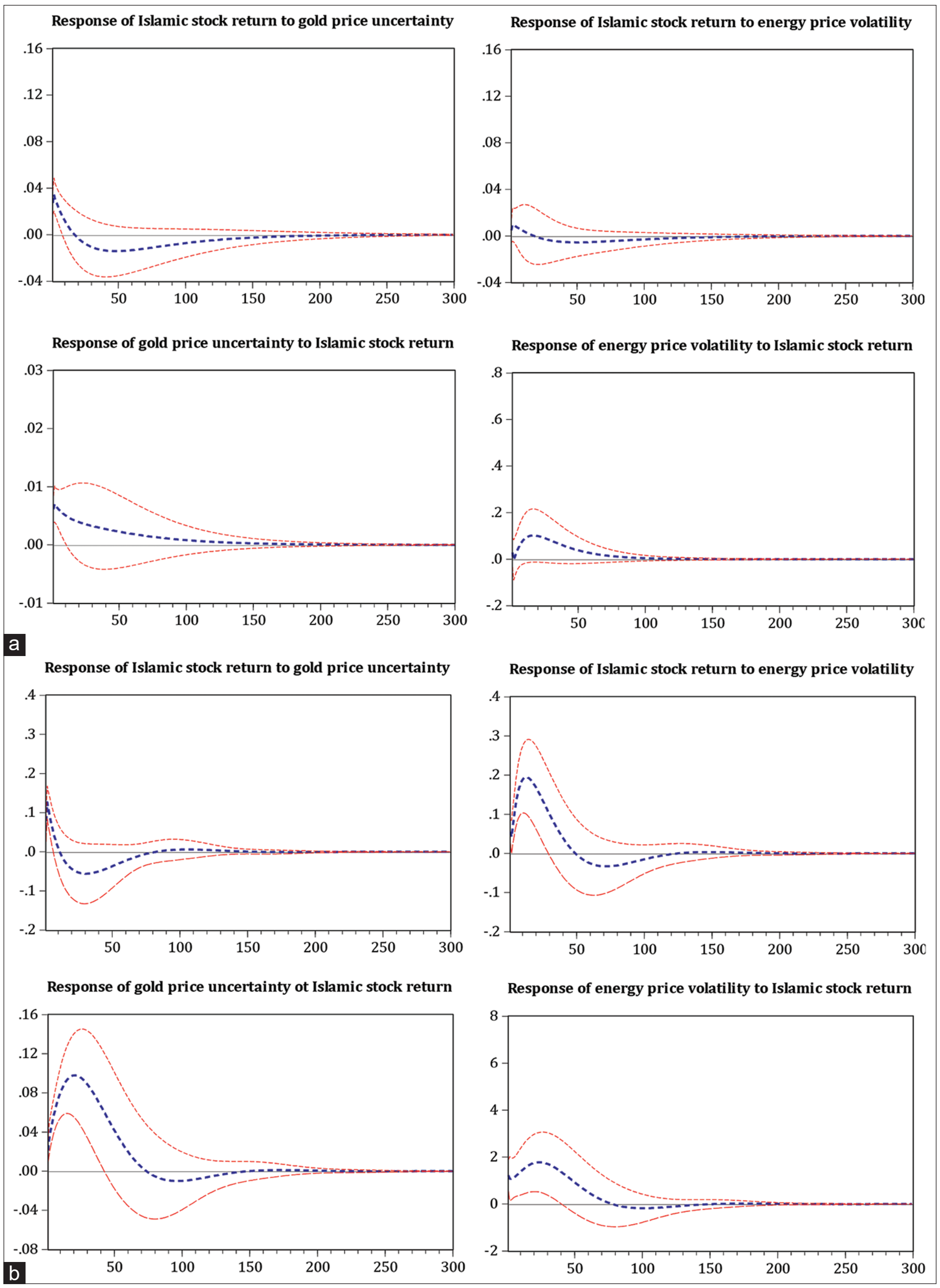


Figure 3: GIRF of Islamic stock price returns under VAR process to a unit shock of gold and energy price volatility, and vice versa. (a) The analytical framework of impulse responses for the pre-pandemic period starts from 2018. (b) The analytical framework of impulse responses for the ongoing-pandemic period starts from 2020



energy price volatility have a positive and statistically significant impacts on Islamic stock market returns, respectively.

Likewise, In Panel (b) of Figure 3 evidence for ongoing-pandemic sample periods shows that Islamic stock market returns have a negative impact on gold price uncertainty reaches up to - 0.1 percent point of the initial unit shocks within 60 and 70 days; full recovery requires up to 90 days from beginning 2020. However, response of Islamic stock market returns have a significant positive effect on energy price uncertainty on first 50 days of pandemic period of January, 2020. After positive impacts, Asia-Pacific Islamic stock market returns seem to have a negative and significant impact on energy price uncertainty, the negative innovation shocks have approximately 40 and 50 days, respectively. In the case of commodity markets, the gold and energy price volatility seem to have a positive and significant impact on the Islamic stock market returns for the ongoing-pandemic sample periods.

6. CONCLUSION

This paper explores the uncertainty effects of the Asia-Pacific DJ Islamic stock market across gold and energy commodities market. Given this, we apply the MGARCH-M model to assess uncertainty effects of the selected market series under study. Model estimations rely on various BEKK and DCC approaches to achieve most robust results. Also, we employ non–causality and the generalized impulse response function analyses.

It should be noted that, in the light of multivariate GARCH–in–mean model estimation, the conditional standard deviation of Islamic stock volatility has a significant positive impact on commodities prices of gold and energy. Moreover, we found the bi-directional adverse volatility spillover effect from the Islamic stock volatility to gold and energy price uncertainty. Asia-Pacific Islamic stock and commodity markets produced a strong performance in Islamic stock market volatiltity dynamics and that the conditional standard deviation was highly volatile for the pandemic period, reaching the highest level in Q2 and Q3 of 2020. Initially, Energy price variability trend gradually increased and grasped it's the highest level in Q2 and Q3, 2020.

Indeed, the results of non-causality tests was revealed bi-directional variance transmissions Islamic stock and the conditional variations of gold and energy for respective Asia-Pacific Islamic stock and commodity markets. Lastly, the computed GIRF functions suggest that the innovation shocks of Islamic stock market returns has a negative impact on gold and energy price uncertainty. The GIRF grows after the shock effect in Asia-Pacific stock and commodities markets and reaches -0.2 and -0.1 percent point of the initial unit shock within 80–120 days; this effects takes around 150 days for fully dissipate in pre-pandemic sample periods. In sum, the response of ongoing-pandemic periods shows Islamic stock price returns have a negative impact on gold price uncertainty from beginning 2020. However, response of Islamic stock market returns have a significant positive effect on energy price uncertainty on first 50 days of pandemic period from January, 2020. After positive impacts, Islamic stock market returns seem to have a negative and significant impact on energy price uncertainty, the negative innovation shocks have approximately 40 and 50 days, respectively. For international investors, the diversification benefits are more evident for investments in the DJ Islamic stock markets.

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