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Volatility Spillovers between Gold Prices, Oil Prices, and the Islamic Stock Market in Pakistan: Evidence from DCC-GARCH and Diebold–Yilmaz Connectedness Analysis

Syed Aqeel Ahmed[1], Roohi Ahmed[2]

[1]*Ph.D Scholar Department of Economics, University of Karachi, Email: syedaqeelahmed6@gmail.com*
[2]*Professor, Department of Economics, University of Karachi, Email: roohia@uok.edu.pk , roohiazeem@yahoo.com*

Abstract

Over the past several years, financial markets and commodity markets have become increasingly interconnected, with shocks in one sector affecting the dynamics of others. As these relationships continue to evolve, understanding how volatility moves from one asset class to another has become increasingly important for making investment decisions, managing risk, and maintaining financial stability. This study investigates the volatility spillovers between real assets and the Islamic stock market in Pakistan by examining the dynamic relationships among KMI-30 Index returns, gold returns, and crude oil returns using weekly data from 2016 to 2025. The EGARCH model is applied to capture volatility persistence and asymmetric market behavior, while the DCC-GARCH model is used to estimate the time-varying correlations among the selected markets. Moreover, the Diebold–Yilmaz spillover index is employed to assess the direction and magnitude of volatility spillovers. The empirical results show that oil returns have a significant association with KMI-30 conditional volatility, whereas gold returns have no statistically significant direct effect in Pakistan. The estimated DCC parameters indicate that the relationships among the KMI-30 Index, gold and oil returns are dynamic and highly persistent over the sample period. However, the spillover analysis reveals that gold acts as a net transmitter of volatility within the connectedness network, while the KMI-30 Index and crude oil act as net receivers. The total connectedness index indicates a relatively low-to-moderate level of market interconnectedness, with volatility spillovers present across the selected markets, and scope for diversification benefits. These results provide valuable guidance to investors, portfolio managers, and policymakers in developing risk management and portfolio diversification strategies.

Keywords: Islamic Stock Market, KMI-30, Gold Prices, Oil Prices, Volatility Spillover, EGARCH, DCC-GARCH, Connectedness, Pakistan.

Introduction

The subject of volatility is a major concern in financial economics because it has a direct impact on investment decision making, policy making and portfolio management. Financial markets have also increased their degree of interconnectedness and linkages between stock markets, commodity markets, and other asset classes have developed close-fitting and increased the rapidity at which shocks and volatility move across markets (Mensi et al., 2017; Diebold et al., 2012).

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Attribution 4.0 International (CC BY 4.0)
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This growing interconnectedness has attracted considerable research interest, particularly in understanding how real assets interact with stock markets during periods of economic uncertainty, geopolitical tensions, inflationary pressures, and global financial crises. (Basher et al., 2015; Ghallabi et al., 2024).

Gold and crude oil are unique among the real assets imported on the world's markets. Gold is considered a safe-haven asset, a potential hedge against financial instability (Baur et al., 2010; Reboredo, 2013) while crude oil is a key commodity that has a significant impact on economic activity and behavior of financial markets (Sadorsky, 2012). Changes in oil prices have impacts on production costs, inflation, exchange rates and investor confidence, which in turn impacts the stock market. Similarly, fluctuations in gold prices can influence the allocation of investments in portfolios and may also impact risk assessments by investors (Chkili, 2022; Chang et al., 2015). Given this, studying the volatility spillovers among these real assets and the stock markets is fundamental to comprehend diversification opportunities and to properly control financial risks (Mensi et al., 2017).

In the past 20 years, Islamic equity markets have grown significantly, and now a significant part of the global financial system. Islamic stock markets differ from conventional stock markets, as they adopt practices that conform to Shariah principles, which has ruled out any interest-based activities and excessive uncertainty. The unique characteristics of Islamic equities imply that such shocks from financial or commodity markets could affect Islamic stocks differently (Nagayev et al., 2016; Sahabuddin et al., 2023). The KMI-30 Index is considered as a proxy for the performance of Islamic stock index in Pakistan. The context of Pakistan, an emerging market economy, is relevant to the analysis of the dynamic relationship between real assets and the Islamic stock market volatility because of the sensitivity of the economy to oil price fluctuations and the developments in the commodity markets.

KMI-30 Index is the main index of the Islamic equity market in Pakistan. The index was launched in 2008 by the Karachi Stock Exchange and Meezan Bank to promote Shariah compliant investment activities on the Pakistan Stock Exchange. It consists of 30 highly liquid and financially robust companies which meet specific ‘shariah screening' criteria and whose index values are calculated using the ‘free float market capitalization' principle. The KMI-30 is different to traditional stock indices as companies that run business operations that are not allowed by Islamic law, for example conventional banks, gambling companies and other incompatible business activities are excluded. Moreover the constituent firms are screened on their financial aspects based on certain criterion such as debt position and non-permissible income, which will enable the index to accurately reflect the Islamic capital market in Pakistan.

KMI-30 Index has become more important due to the growth of Islamic financial in the country. The increasing number of Shariah compliant listed companies has made the index an important benchmark for investors, fund managers, and Islamic financial institutions. It is also widely used as a benchmark for a range of Islamic investment products. Although it has a Shariah-based structure, the performance of the index is still affected by general economic and financial changes. Investor behavior and market performance can be influenced by fluctuations in oil prices, commodity markets, and geopolitical events. Therefore, it is essential to study the relation between the KMI-30 Index and major real assets in order to have an insight of volatility dynamics, investment risk and financial stability in Islamic financial system in Pakistan.

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Several previous studies have examined the relationship between commodity markets and stock market volatility in both conventional and Islamic financial environments. For Pakistan, Qureshi et al., (2019) found that there were strong cross-market interactions among the gold price, exchange rates, and sectoral stock returns, with high volatility spillovers between them. Erdoğan et al., (2020) also reported such findings by discovering volatility spillovers among Islamic stock markets and exchange rates of emerging economies. Similarly, Ghallabi et al., (2024) found significant risk spillovers from commodity markets to Islamic equity markets, especially during financial stress and uncertainty.

The study contributes to the existing literature in several ways. It is focused on the Islamic stock market of Pakistan and it provides additional evidence on the relationship between real assets and the Shariah compliant equity market in an emerging market. Another important contribution lies in the methodological approach adopted in the analysis. The study uses EGARCH, DCC-GARCH and Diebold–Yilmaz spillover analysis in order to analyze market behavior from various perspectives. The unified framework enables the study of volatility persistence, asymmetric volatility reactions to market shocks, dynamic correlations and volatility transmission all within one framework. The results are anticipated to help investors and portfolio managers to assess diversification potential and to gain insights into the propagation of volatility in markets. The research also provides valuable policy modules to regulators, policy makers and other market participants who are interested in financial stability and efficient risk management.

The rest of this research paper is organized as follows. A literature review is included in the next section, and the data and methodological framework used in the analysis is discussed. The next section summarizes the findings from this study and the final section summarizes the main conclusions and the policy implications.

Literature Review

Interest in transmission of shock and volatility to various asset classes has risen with the global financial and commodity markets becoming more integrated. Researchers have been studying the relationship between commodity markets and stock markets, as commodity prices are important factors that can influence investment decisions, portfolio allocation and financial stability. Specifically, the relationship between oil prices, gold prices and the performance of the stock market has been great interest to academics. Previous research has used a range of econometric methods to explore these relationships, such as GARCH models, Vector Autoregressive (VAR) models, and connectedness or spillover analysis.

Since the early 1980s, research into financial market volatility has grown significantly. However, a significant advance was achieved by Engle (1982) by proposing the autoregressive conditional heteroskedasticity (ARCH) model which offers a systematic framework for studying time-varying volatility in financial and economic time series. Although the ARCH model represented an important advancement, its ability to capture persistent volatility remained limited. This limitation was addressed by Bollerslev (1986) who introduced the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model that explicitly made use of past shocks and past volatility in the estimation. This development enabled researchers to explain the persistence of volatility more effectively. Nelson (1991), who extended it to the Exponential GARCH (EGARCH) model that was able to incorporate a leverage effect and allowed volatility to re-

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spond differently to good and bad market information. Another advancement was due to Glosten et al., (1993) and Zakoïan (1994) who proposed the GJR-GARCH model and TGARCH model, respectively, to incorporate the asymmetric market reactions. They showed that negative information can have a larger impact on volatility than positive information of the same magnitude.

Gradually as the financial markets became more interconnected, the focus started to move from modelling the volatility of individual assets to understanding the evolving relationship between several financial instruments. Tse and Tsui (2002) proposed a multivariate GARCH model which allowed for time-varying correlation parameters, which is a more realistic model of financial market behavior. The DCC-GARCH model, developed by Engle (2002), was a flexible model that allowed to capture the changing market relationships, and this model rapidly became one of the most widely used models in financial research. In a later study, Bauwens et al., (2006) gave a thorough evaluation of multivariate GARCH models and highlighted their application in studying volatility transmission, market interdependence and risk spillovers. In combination, these methodological advances have improved our understanding of the nature of financial market dynamics and have equipped us with useful instruments for portfolio diversification, risk management, and the analysis of market integration.

The increasing interconnectedness of the financial markets stimulated the development of methods that would allow to quantify the flow of shocks and volatility between markets. Diebold and Yilmaz (2009) pioneered an index framework of spillovers related to return and volatility transmission by developing a spillover index approach that uses forecast error variance decompositions. In an effort to broaden the framework, their next study (Diebold & Yilmaz, 2012) added measures of directional spillovers, allowing them to discern whether markets are major transmitters of shocks or major receivers of shocks. Building on the development of the research on connectedness, Barunik and Krehlik (2018) further extended the analysis by separating spillovers by their short, medium, and long-term frequencies. Recently, Antonakakis et al., (2020) provided a new framework called the Time-Varying Parameter Vector Autoregression (TVP-VAR) that overcame the limitations of rolling-window estimation and introduced time-varying connectedness. Moreover, Gabauer (2021) developed and provided practical implementation of these methodologies in the connectedness approach package for R, thus enabling more advanced connectedness analysis to be used by researchers. These methodological developments have significantly enhanced the understanding of financial market dynamics and provided valuable tools for portfolio diversification, risk management, and the analysis of market integration.

Empirical evidence in recent years has given additional support to the existence of high levels of interconnectedness between commodity, equity and Islamic financial markets. There is a growing frame of research that indicates shock transmission is dynamic and depends on market conditions. For instance, Mensi et al., (2022) found that oil price and the Islamic sectoral stocks are spilling over significantly across different frequencies, especially during the high economic uncertainty period. A similar result was found by Khokhar et al., (2023) who found significant cross-interdependence of gold, oil and the Islamic equity market. Their results revealed that oil was the most important transmitter of volatility, whereas gold maintained its role as good hedging instrument. Sahabuddin et al., (2023) also showed that volatility spillovers between equity markets become more pronounced during financial crises, which diminishes the diversification gains among the markets. Similarly, Ghallabi et al., (2024) found that oil and gold have an im-

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pact on the Islamic equity markets, but oil has a relatively larger impact on the volatility of the Islamic equity markets, while gold remains important as a diversification vehicle.

Recent empirical evidence has provided further support for the existence of strong interconnectedness among commodity, equity, and Islamic financial markets. This is particularly relevant to the study on strong cross-market linkages by Mughal and Roubaud (2021) between oil prices, exchange rates and stock markets in the emerging economies, highlighting the significance of cross-market linkages in investment and risk management decisions. In this regard, Agrawal et al., (2025) analyzed the long-term connections between stock markets, gold prices, oil prices, exchange rates, and natural gas markets. They found that some assets have diversification benefits in the short term, but that the longer-term the more these diversification benefits are reduced with greater market integration. The evidence gathered in the above segments suggests a dynamic relationship between commodity market, exchange rates and Islamic equity markets, which tends to become stronger during financial and economic distress.

Specifically, in Pakistan, several studies have been conducted to examine the impact of commodity prices, exchange rate, and macroeconomic conditions on the stock market. The function of gold as a hedge and safe-haven asset to the fluctuations in stock returns, oil prices and exchange rates has attracted specific attention, as Chang et al., (2015) have shown how effective gold is as a hedge asset. Their results indicate that gold can be a valuable asset to help investors handle uncertainty and diversify their portfolios. Jebran and Iqbal (2016) studied the transmission of volatility from the stock to the foreign exchange market in Pakistan and some Asian economies with the EGARCH methodology. The findings showed that there is a high degree of bidirectional spillovers, indicating the strong link between currency and equity markets.

Further studies also confirmed the impact of commodity and macroeconomic variables on the performance of the stock market in Pakistan. Shabbir et al., (2020) found that oil prices and gold prices had a significant long-run relationship, which implies that an increase in oil prices could negatively affect the performance of the stock market but gold provides diversification opportunities. Qureshi et al., (2019) presented a similar finding that volatility spillovers of gold prices and exchange rates to the returns of sectoral stocks with varying intensities across the sectors analyzed. Aziz and Hussain (2021) also found significant volatility spillovers between stock prices, oil prices and gold prices, highlighting the interdependence of Pakistan's financial markets.

Oil and gold prices impact on equity performance has been extensively studied in the case of Pakistan. Current evidence tends to support the importance of commodity markets in influencing the behavior of the stock market and investment results. For example, Shabbir et al., (2020) found that gold prices have positive effects on the stock market while the oil prices have negative effects because of the effect that they have on the production costs and economic activities. Jamil et al., (2021) also provided evidence of the financial market interdependence by finding that there are substantial bidirectional volatility spillovers between stock and foreign exchange markets, especially in the stage of structural changes.

Later studies have extended the analysis to include a larger set of macroeconomic and financial data. In this context, Khokhar et al., (2023) investigated the joint impact of gold prices, oil prices, exchange rates, interest rates and commodity market volatility on the stock market of Paki-

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stan. They found volatility from oil markets has destructive effects on stock market performance, whereas volatility from gold markets has positive long-term effects. Similarly, Arshad (2025) highlighted the significance of macroeconomic stability on the performance of the stock market by showing that exchange rate, oil price, inflation, and interest rate have negative impact on the performance of the stock market. The results of the above studies indicate that the price of commodities, exchange rates and macroeconomic environment continue to be significant factors affecting volatility and investment returns in the Pakistani stock market.

Existing literature has widely studied the commodity markets and volatility of financial markets, but there is little empirical evidence on the relationship between real assets and Islamic stock market in Pakistan. Furthermore, past studies frequently have adopted a single modelling approach in the analysis of market interconnectedness. There is relative insufficiency of research that link volatility modelling, dynamic correlation and spillover measurement in an empirical framework. Therefore, a changing volatility transmission and market connectedness may not be adequately reflected. To fill these gaps, in this study, the volatility spillovers and dynamic connectedness between KMI-30 returns, gold returns, and crude oil returns are explored using weekly data of the period 2016 to 2025.

Research Methodology

Data Description

The aim of this study is to examine the spillovers effect of real assets volatility on the Islamic stock market in Pakistan by employing the weekly data from 2016 to 2025. The variables selected are the returns on the KMI 30 Index, Gold prices and Crude Oil prices. The KMI-30 index is an index of Islamic stocks in Pakistan and gold and crude oil are major real assets as they play a vital role in the global financial markets and investment portfolios. Historical gold and crude oil prices data is from Investing.com, gold is measured in U.S. dollars per troy ounce, and crude oil is measured by the international benchmark, in USD per barrel. The KMI-30 index data has been obtained from the Pakistan Stock Exchange (PSX).

Volatility analysis using weekly data presents a number of benefits. Weekly data are less influenced by excessive market noise and short term irregular fluctuations, and thus better represent underlying market behavior. Moreover, the weekly data are suitable for studying medium-term market dynamics, as well as the transmission of the volatility among the selected variables. All closing price series are transformed into log returns to analyze the data empirically. This transformation is frequently used in financial studies because it helps to improve the stability of variance and to reduce the non-stationarity data in financial time-series data. The continuously compounded return formula is used to calculate the return series:

$$R_t = ln\,(P_t / P_{t-1}) \times 100 \qquad (3.1)$$

where:

- R_t represents the return at time (t),
- P_t denotes the current price,
- P_{t-1} indicates the previous period price,

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- *ln* represents the natural logarithm.

Descriptive Statistics and Correlation Analysis

Descriptive statistics analyze to the main statistical features of the return series. The mean, standard deviation, skewness, kurtosis, and Jarque-Bera test values are included in these statistics. These measures together, offer an initial overview of the distributional properties, volatility patterns and overall behavior of the selected variables.

Moreover, the level of linear association between KMI-30 returns, gold returns and oil returns is also tested with a correlation analysis. It is crucial to understand these relations as the presence of positive or negative correlations could affect diversification opportunities, hedging strategies and volatility transmission channels of financial markets (Baur and Lucey, 2010). The resulting correlation matrix provides valuable information regarding the level of interdependence of the market and is an initial measure of diversification opportunities among the chosen assets.

Unit Root Test

The unit root test (Augmented Dickey-Fuller test) is applied to check the stationarity of the variables before estimation of the volatility models. When time-series variables are non-stationary, conventional regression analysis may produce spurious or misleading results, leading to incorrect inferences about the relationships among the variables. Testing for stationarity is an important step in time-series analysis. The ADF test is used to check for stationarity and appropriateness of the return series for further econometric modelling. The test equation for the ADF can be written like this:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t \quad (3.2)$$

where:

- ΔY_t denotes the first difference of the variable,
- α represents the constant term,
- β_t is the time trend,
- γY_{t-1} is the lagged level variable,
- ΔY_{t-i} are lagged difference coefficients,
- δ Coefficients of lagged difference terms
- p Optimal lag length,
- ε_t is the error term.

The null hypothesis of the ADF test states that the series contains a unit root (non-stationary), while the alternative hypothesis indicates stationarity.

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Autoregressive Conditional Heteroskedasticity (ARCH-LM) Test

Once a return series has been proven to be stationary, the next step is to identify if volatility clustering and conditional heteroskedasticity exist in the data. Financial time series often have phases of high volatility followed by high volatility and phases of low volatility followed by low volatility (Engle, 1982). This is known as volatility clustering, and is an assumption that is not captured by the standard linear regression models, forcing the use of volatility modelling techniques.

This study uses the conditional heteroskedasticity Lagrange Multiplier (ARCH-LM) test designed by Engle (1982) to test for the presence of conditional heteroskedasticity. The ARCH-LM test is a popular test in financial econometrics for presence of ARCH effects in the residual process of a time-series model. The detection of ARCH effects suggest that the error term variance is time-varying and related to past information, which is appropriate to be fitted by ARCH-type and GARCH-type volatility models.

The ARCH process can be represented as:

$$\sigma^2_t = \alpha_0 + \alpha_1\varepsilon^2_{t-1} + \alpha_2\varepsilon^2_{t-2} + \ldots + \alpha_p\varepsilon^2_{t-p} \qquad (3.3)$$

where:

σ^2_t denotes the conditional variance at time (t),
α_0 represents a constant term,
$\varepsilon^2_{t-1} + \varepsilon^2_{t-2} + \ldots + \varepsilon^2_{t-p}$ represent lagged squared residuals,
$\alpha_1, \alpha_2, \ldots, \alpha_p$ measure the impact of past shocks on current volatility.

The decision rule is related to the probability value of the ARCH-LM statistic. If the probability value is less than the selected significance level of 5%, the null hypothesis is rejected, indicating the presence of ARCH effects and time-varying volatility. If the null hypothesis is not rejected, then there is no conditional heteroskedasticity.

EGARCH Model

The study uses the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model suggested by Nelson (1991) to model the volatility clustering and the asymmetric behavior in financial returns. The EGARCH model is especially appropriate for the case of financial and commodity returns series where volatility has the property of reacting differently to positive and negative shocks. This type of asymmetric behavior is common in financial markets where bad news may be more relevant to volatility than good news of a same size. Other recent research has also used EGARCH models to examine volatility transmission between commodity and financial markets, such as that of Terraza et al., (2024) and Ghallabi et al., (2024). The EGARCH specification is shown to offer a better framework for the modelling of leverage effects and asymmetric responses in volatility than the traditional GARCH model proposed by Bollerslev (1986). The EGARCH model is more realistic in capturing the behavior of the financial market than the traditional symmetric volatility models as the market often responds in an asymmetric way to market information.

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The standard mean equation of EGARCH (1 1) can be represented as:

$$R_t = \mu + \varepsilon_t \qquad (3.4)$$

where:

R_t denotes the return series,
μ represents the conditional mean,
$\boldsymbol{\varepsilon_t}$ is the error term**.**

The mean equation forms an integral part of the EGARCH specification; however, the primary focus of this study is not the prediction of expected returns but the analysis of conditional volatility dynamics. Accordingly, greater emphasis is placed on the variance equation, as the behavior, persistence, and asymmetry of conditional volatility are central to the objectives of the study.

The EGARCH(1,1) variance equation is expressed as:

$$\ln(h_t) = \omega + \beta \ln(h_{t-1}) + \alpha \left(\left| \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right| - E \left| \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right| \right) + \gamma \left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right) \qquad (3.5)$$

where:

- $\ln(h_t)$ represents conditional variance,
- ω is the constant term,
- $\beta \ln(h_{t-1})$ measures volatility persistence,
- $\alpha|\varepsilon_{t-1} / \sqrt{h_{t-1}}|$ captures the magnitude effect of shocks,
- $\gamma(\varepsilon_{t-1} / \sqrt{h_{t-1}})$ measures the asymmetric or leverage effect,
- ε_{t-1} represents lagged residuals.

Among the biggest merits of the EGARCH model is the logarithmic specification of variance. The conditional variance is modelled in the log form, which means that non-negativity constraints on variance parameters are not needed. This feature makes it more flexible to model financial market volatility (Nelson, 1991).

The meaning of the asymmetry coefficient (γ) is significant especially. If γ is negative and statistically significant, a leverage effect is said to exist and a negative shock would have a greater impact on the future volatility of the stock price than a positive shock of a similar magnitude. In contrast, having a positive coefficient implies that positive shocks have greater effects on volatility.

This study relies on the following assumptions with the EGARCH model. First, the return series has to be stationary. Second, the residuals should show conditional heteroskedasticity as verified with the ARCH-LM test. Third, volatility is assumed to vary over time in a dynamic manner and to rely on past information. Lastly, volatility could be responsive to positive and negative shocks in an asymmetric manner. To test whether the return behavior of gold and oil have significant

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impact on the volatility behavior of the Islamic stock market in Pakistan, the EGARCH model has been estimated.

Dynamic Conditional Correlation (DCC-GARCH) Model

This study uses the Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model proposed by Engle (2002) to explore the dynamic volatility relations and time-varying correlation between KMI-30 returns, gold returns and oil returns. The power of capturing the changing relationships between financial assets has led to the extensive use of the DCC-GARCH approach in the analysis of the interconnectedness of financial and commodity markets, such as in the works of Nagayev et al., (2016), Mensi et al., (2017), and Ghallabi et al., (2024).

The DCC-GARCH model has two steps. The first stage is to estimate the univariate GARCH models to estimate the conditional variance of each return series. The second stage concerns the estimation of the conditional correlation matrix in a dynamic approach.

The variance-covariance matrix is expressed as:

$$H_t = D_t R_t D_t \qquad (3.6)$$

where:

- H_t denotes the conditional covariance matrix,
- D_t is the diagonal matrix of conditional standard deviations,
- R_t represents the time-varying conditional correlation matrix.

The dynamic correlation process is estimated using:

$$Q_t = (1 - a - b)\,\bar{Q} + a\,(\varepsilon_{t-1}\,\varepsilon'_{t-1}) + b\,Q_{t-1} \qquad (3.7)$$

where:

- Q_t is the dynamic covariance matrix,
- $(1 - a - b)\bar{Q}$ denotes the unconditional covariance matrix,
- $a(\varepsilon_{t-1}\,\varepsilon'_{t-1})$ measures short-run shock effects,
- bQ_{t-1} measures volatility persistence.

The DCC-GARCH framework is based on several assumptions. First, all return series need to be stationary. Second, there should be volatility clustering in the data. Third, dynamic correlations are estimated using conditional variances that are estimated by univariate GARCH-type models. Fourth, correlations are assumed to evolve systematically over time in response to new information and past correlation structures. The DCC-GARCH model is particularly useful because it captures the evolving correlations among financial markets over time rather than assuming constant relationships.

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Spillover Analysis

The study used the Diebold-Yilmaz spillover index approach as well to examine the direction of volatility transmission and the magnitude of volatility transmission among markets. This approach quantifies how much shocks to one market affect the volatility of other markets. The total spillover index is computed as follows:

$$S^H = \frac{\sum_{i,j=1, i \neq j}^{N} \theta_{ij}^H}{\sum_{i,j=1}^{N} \theta_{ij}^H} \times 100$$

Where:

- S^H = total spillover index
- θ_{ij}^H = forecast variance decomposition
- N = number of variables

The spillover framework allows the identification of:

- Net volatility transmitters,
- Net volatility receivers, and
- Overall market connectedness.

The Diebold–Yilmaz approach consists of the estimation of total, directional, and net spillover effects that offer a comprehensive measure of market connectedness. Spillover analysis is different from traditional correlation analysis because it identifies the direction of shock transmission and distinguishes between volatility transmitters and volatility receivers. This approach is helpful in the study of dynamic interactions between the Islamic stock market, gold market and oil market in Pakistan.

Results and Discussion

Descriptive Statistics

Table 1 shows descriptive statistics of the weekly returns of the KMI-30 Index, gold, and crude oil. The results indicate that KMI-30 Index have the highest average return (0.002933) for the sample period as compared to gold (0.002639) and crude oil (0.000801). This implies that the average return of Islamic stock market is higher in comparison to the selected commodity assets. Thus, the investors in the KMI-30 Index are able to get relatively higher returns than the investors in gold and crude oil during the study period.

Table 1 Descriptive Statistics of KMI-30, Gold and Oil Returns

Statistics	KMI Returns	Gold Returns	Oil Returns
Mean	0.002933	0.002639	0.000801
Median	0.004288	0.002842	0.004379
Maximum	0.143974	0.105757	0.248053

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Minimum	-0.163812	-0.098088	-0.404577
Std. Dev.	0.030609	0.020985	0.058457
Skewness	-0.088897	0.089553	-0.884056
Kurtosis	6.242157	5.451553	11.0798
Jarque-Bera	228.4359	130.9142	1482.204
Probability	0.000	0.000	0.000
Observations	520	520	520

Source: Author's calculations using EViews based on weekly data (2016–2025)

There are distinct differences in the volatility level of the three markets as evident from the standard deviation values. The highest volatility is seen in crude oil (0.058457), followed by the KMI-30 Index (0.030609), and the lowest volatility is seen in gold (0.020985). This means that the oil market have greater price volatility than the Islamic stock market and the gold market over the period of study. However, gold market much lower volatility suggests it is comparatively stable and could be used as a save asset in portfolio diversification.

All three Indexes have a kurtosis value greater than the normal value of three, the KMI-30 Index (6.242157), gold (5.451553), and crude oil (11.07980). This means that the price returns are leptokurtic, with the extreme price returns happening more often than they would in a normal distribution. Heavy-tailed distribution and volatility clustering are suggested by the high kurtosis, supporting the application of ARCH family models. The value of the kurtosis for crude oil is particularly high, indicating the oil market have a significant shocks and sharp price movements during the sample period. Overall, the descriptive statistics indicate that the selected markets do not follow a normal distribution and they are characterized by periods of changing volatility. These results are in line with the typical behavior of financial return series as seen in the literature, such as for example Mensi et al., (2017).

The return series of the KMI-30 Index, gold, and crude oil price are shown in Figure A1. The figure reveals that periods of high and low volatility have occurred in all three markets indicate presence of volatility clustering. There are also a number of high positive and negative movements, particularly in the economic and geopolitically uncertainty. Of the three, crude oil seems to be the most unpredictable, with comparatively smaller fluctuations in gold. The evidence is also indicative of the presence of heteroskedasticity, with periods of high movements followed by periods of high movements and the reverse. The pattern suggests that there is heteroskedasticity and justifies the use of ARCH family models to investigate the behavior of volatility and spillover effects.

Correlation Analysis

The correlation matrix for the selected variables is given in table 2. The results show that there is a weak positive correlation between the gold returns and KMI-30 returns (r = 0.0306), and between oil returns and KMI-30 returns (r = 0.1283). The relationship between gold and oil returns, on the other hand, discovered to be weakly negative (-0.0696).

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Table 2 Correlation Matrix

Variables	KMI Returns	Gold Returns	Oil Returns
KMI Returns	1	0.0306	0.1283
GOLD Returns	0.0306	1	-0.0696
OIL Returns	0.1283	-0.0696	1

Source: Author's calculations using EViews.

The low values of the correlation coefficient suggest that the three markets are short-run, weakly interconnected. This indicates that investors can gain from diversification by incorporating them into their investment portfolio. The weak correlations also suggest that the linkage between the markets is not time-invariant and may adjust to the changing economic and financial conditions. So, the use of static correlation measures may not give a full picture of the interactions among markets. This makes it appropriate to employ dynamic correlation models that are more appropriate to identify market relationships over time. In line with this, Nagayev et al., (2016) and Ghallabi et al., (2024) also reported relatively lower correlation between commodity market and Islamic equity market, which could benefit from diversification of the portfolio.

Unit Root Test

The Augmented Dickey-Fuller (ADF) unit root test is applied to the return series to test its stationarity. The results presented in Table 4.3 indicate that the ADF test statistics for all three return series are significantly negative, with values of −21.7504 for KMI-30 returns, −24.1322 for gold returns, and −21.1320 for oil returns. Furthermore, all the probabilities have a value of (0.0000) which is significant at the 1% level. Thus all the variables are stationary at level.

Table 4.3 Augmented Dickey-Fuller (ADF) Unit Root Test Results

Variable	ADF Statistic	p-value	Result
KMI Returns	-21.7504***	0.000	Stationary at Level I(0)
GOLD Returns	-24.1322***	0.000	Stationary at Level I(0)
OIL Returns	-21.1321***	0.000	Stationary at Level I(0)

Source: Author's calculations using EViews.
Note: *** indicates significance at 1%

The stationarity of the variables satisfies the prerequisite condition for GARCH-based volatility modeling and ensures the reliability of further econometric estimation.

ARCH-LM Estimation Results

The results of the ARCH-LM test are presented in Table 4 the estimated F-statistic is (23.9461) with a probability value of (0.0000). Likewise, the Obs*R-squared statistic is (22.9746) and is also related to a probability value of (0.0000). The values of both probabilities are less than 1% so the null hypothesis is rejected (homoskedasticity).

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Table 4 Pre ARCH-LM Test Results

Test Statistic	Value	Probability
F-statistic	23.9461***	0.000
Obs*R^2	22.9746***	0.000

Note. *** indicates significance at 1%

The results verified the existence of substantial ARCH effects in the return series, which suggest that the volatility is not stable over time. This is the common practice in financial markets and is considered as evidence of volatility clustering. So the volatility dynamics of the selected variables are suitable to be analyzed by using ARCH family models like EGARCH and DCC-GARCH.

EGARCH (1,1) Estimation Results for KMI-30 Returns

The EGARCH model is estimated to get insights into the volatility dynamics between real and Islamic stock market in Pakistan. The empirical results show that the return series exhibit strong ARCH and GARCH effects, suggesting the presence of volatility clustering and persistence in the return series.

Table 5 EGARCH Estimation Results

Variable	Coefficient	Std. Error	z-Statistic	p-value
Mean Equation				
Constant (C)	0.0036***	0.0013	2.8472	0.0044
Variance Equation				
Constant (ω)	-2.0401***	0.5966	-3.4194	0.0006
ARCH Effect (α)	0.2582***	0.0634	4.0702	0.0000
GARCH Effect (β)	0.7416***	0.0806	9.1958	0.0000
Leverage Effect (γ)	-0.1083***	0.0365	-2.9694	0.0030
Gold Returns (δ_1)	-0.8057	1.9710	-0.4088	0.6827
Oil Returns (δ_2)	-3.0658***	0.8991	-3.4099	0.0006
Model Evaluation Statistics				
Statistic			**Value**	
Log-Likelihood			1.11729	
Akaike Information Criterion (AIC)			-4.27033	
Schwarz Information Criterion (SIC)			-4.21306	
Hannan–Quinn Criterion (HQC)			-4.24790	
Observations			520	

Source: Author's calculations using EViews.
Note: *** indicates significance at 1%

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$$KMI_RET_t = \mu + \varepsilon_t \quad (4.1)$$

The EGARCH (1,1) estimation results in Table 5 show that the KMI-30 Islamic stock index display a significant volatility dynamics in the sample period 2016-2025. The estimated constant in the mean equation is positive (0.0036) and significant on 1% level of significance (p = 0.0044) showing that the weekly mean return of the Islamic stock market is positive during the study period. The result shows the overall strength of equity markets in Pakistan, which are Shariah compliant, in spite of times of economic turbulence such as exchange rate depreciation, inflationary pressures, the COVID-19 pandemic and geopolitical turmoil. The positive mean return indicates that market risk is being compensated with a positive return by the investors in the KMI-30 index.

$$\ln(h_t) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right| + \gamma \left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right) + \beta \ln(h_{t-1}) + \delta_1 GOLD_RET_t + \delta_2 OIL_RET_t \quad (4.2)$$

Within the variance equation, the ARCH coefficient (α = 0.2582) is positive and highly significant **(**p < 0.01), confirming the presence of short-run volatility persistence. This finding suggests that the market shocks from the earlier periods have an important impact on the volatility of assets in the current period, which means that the recent information becomes quickly integrated into the asset prices. The outcomes of this research is economically significance to the Pakistan context, as the stock market is very sensitive towards the macroeconomic announcements, political uncertainty, monetary policy decisions and the movements in international commodity prices. As a result, a sudden change of events either domestically or internationally can immediately raise the uncertainty of the market and the volatility of the short-term market. Similar evidence of significant short-run volatility transmission has been documented by Aziz and Hussain (2021) for Pakistan and by Kang et al., (2023) for commodity-equity market interactions.

The GARCH coefficient is also positive (0.7416) and highly significant (p<0.01) suggesting a high persistence of long-run volatility in the KMI-30 index. More importantly, the combined magnitude of the ARCH and GARCH coefficients (α + β = 0.9998) indicates that volatility shocks are highly persistent. Although the magnitude is below unity, suggesting that volatility eventually converges to its long-run equilibrium, the relatively high coefficient implies that volatility shocks dissipate only gradually over time. A persistent reflects a consequence of the long-term effects of inflation, fluctuations in exchange rate, energy prices, and political uncertainty on investor expectations, from a Pakistani perspective. Pakistan being an emerging market with lower liquidity than developed financial markets, sometimes moments of increased uncertainty for several weeks before market conditions get back to normal. The same characteristics of the persistence of volatility have been documented by Chkili (2022), and Adekoya et al., (2022) who found that volatility persistence is a common feature of Islamic equity markets.

The asymmetric (leverage) coefficient (γ = -0.1083) is negative and statistically significant (p = 0.0030) indicating the presence of significant leverage effect in the KMI-30 Islamic stock market. The negative coefficient means that negative shocks lead to a larger increase in volatility in the future than positive shocks of the same size. This indicates that investors are more sensitive to negative information, like inflation, political turmoil, devaluation of the currency, or higher in-

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ternational oil prices, as compared to positive information in the economic sector. This investor asymmetry behavior is common in less developed financial markets where uncertainty and information asymmetry is higher. The result is in line with Aziz and Hussain (2021), Chkili (2022) and Bhatti et al., (2023), who found asymmetric reactions of equity markets to commodity price shocks as well.

As for the coefficient of gold returns is negative (-0.8057) and statistically insignificant (p = 0.6827), which means that changes in gold prices in the international market do not have a direct influence on the volatility of the KMI-30 index during the sample period. From an economic point of view, this indicates that even though gold has been viewed as a "safe" investment, Pakistani Islamic equity investors do not systematically rebalance their portfolios between gold and Shariah-compliant equities as gold prices change. This relatively weak relationship could also be attributed to the lesser integration between the gold market and Islamic equity market in Pakistan. Therefore, gold seems to offer diversification benefits and not to directly affect volatility to the KMI-30. Similar findings were reported by Aziz and Hussain (2021) who concluded that there are no significant spillover effects of gold on the stock market and by Chkili (2022) who suggested that the main motive of investing in gold during financial uncertainty is to diversify in the portfolio.

On the other hand, the coefficient of the oil returns variable is negative (-3.0658) and highly significant, with (p = 0.0006), which suggests that the volatility dynamics of the KMI-30 Islamic stock index is significantly related to changes in international oil prices. The result has significant economic consequences for Pakistan as the nation is very reliant on crude oil imports to fuel its energy needs. A rise in oil prices will lead to higher production costs, higher transportation costs, higher inflation, and higher operating costs for industries, which will lead to increased uncertainty for investors. Consequently, the external shocks of oil prices are quickly cascaded through the Islamic equity market in Pakistan, thus making oil one of the most influential external factors affecting the volatility in the market. In line with this, Bhatti et al., (2023) reported similar results, and Ali et al., (2022) found that stock market volatility is significantly influenced by changes in oil prices, especially in oil importing emerging economies.

Overall, EGARCH results confirm the presence of volatility clustering, persistence, and asymmetric volatility in Pakistan's Islamic stock market. Additionally, the results suggest that oil prices are a major cause of external volatility, while gold prices do not show statistically significant direct transmission of volatility. The findings show that the KMI-30 index volatility behavior is driven by both internal market conditions as well as external commodity price shocks. Based on this evidence, the Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model is used in the next analysis to study the time-varying correlation between the KMI-30 index and gold and oil prices, as well as the time-varying volatility spillovers.

Table 6 Post-Estimation ARCH-LM Test

Test Statistic	Value	Probability
F-statistic	1.4870	0.2232
Obs*R^2	1.4885	0.2225

Source: Author's calculations using EViews.

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The results shown in Table 6 F-statistic is (1.4870) with a probability value of (0.2232). In the same way, the Obs*R-squared statistic is equal to (1.4885) with a probability value of (0.2225). Both probability values are above the usual 5% significance level suggesting that the null hypothesis of no remaining ARCH effects cannot be rejected. The findings suggest that the EGARCH model has successfully captured the time-varying volatility present in the return series.

Dynamic Conditional Correlation (DCC-GARCH) Results

The estimated parameters of the DCC-GARCH model for KMI-30 Islamic stock index, gold returns, and oil returns are reported in Table 7 for the time span 2016–2025. The model includes the parameters of univariate GARCH for every market and the Dynamic Conditional Correlation (DCC) parameters that describe the evolution of the time-varying correlations between the three markets.

Table 7 DCC-GARCH Estimation Results

Parameter	Estimate	Std. Error	t-Statistic	p-value
KMI μ	0.003313***	0.001253	2.644400	0.008200
KMI α_1(ARCH)	0.231242***	0.077418	2.986900	0.002800
KMI β_1(GARCH)	0.377109**	0.165957	2.272300	0.023100
Gold μ	0.001862	0.001031	1.805000	0.071100
Gold α_1(ARCH)	0.113104	0.173678	0.651200	0.514900
Gold β_1(GARCH)	0.761545	0.738263	1.031500	0.302300
Oil μ	0.001029	0.002017	0.510200	0.609900
Oil α_1(ARCH)	0.169847***	0.053361	3.183000	0.001500
Oil β_1(GARCH)	0.660863***	0.063728	10.370100	0.000000
DCC α (dcca1)	0.000000	0.000059	0.000400	0.999700
DCC β (dccb1)	0.906784***	0.222717	4.071500	0.000000

Model Evaluation Statistics	
Statistic	**Value**
Log-Likelihood	3209.633
Akaike Information Criterion (AIC)	-12.279
Bayes Information Criterion (BIC)	-12.14
Shibata Criterion	-12.281
Hannan–Quinn Criterion (HQC)	-12.225

Source: Author's estimation of DCC-GARCH model. Using R software
Note: *** represents the magnitude of significance at 1% level
** represents the magnitude of significance at 5% level

The mean average return of KMI-30 index (μ = 0.003313) is positive and statistically significant at 1% level (p = 0.0082) indicating that the weekly returns of Pakistan's Islamic equity market are positive on an average basis during the sample period. The Islamic stock market achieved positive long-term returns despite a lot of negative economic events such as inflation hikes, depreciation of exchange rate, political turbulence and impact of COVID-19. This is a confirmation of the fact that, in spite of an uncertain macroeconomic environment, investment opportunities

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are still available for Shariah-compliant firms. This finding has been confirmed by Chkili (2022) and Sahabuddin et al., (2023), who found that Islamic equity markets showed better performance during the financial crisis in general due to their lower leverage and Shariah screening principles.

The estimated ARCH coefficient of KMI-30 is positive ($\alpha_1 = 0.231242$) and the corresponding p-value (0.0028) is significant at level of 1%, suggesting a short-run impact of recent market shocks on market volatility. It implies that new information coming into the market is reflected quickly into the price of Shariah-compliant stocks. Such behavior usual in Pakistan, where investors keep an eye on the monetary policy decisions, foreign exchange rate movements, the international price of commodities, and political developments. Unexpected news generally results in quick shifts in market sentiment and short-term fluctuations in volatility in the markets. The finding was corroborated by Aziz and Hussain (2021) and Bhatti et al., (2023) who also reported that the equity market in Pakistan is quick to respond to domestic and international economic shocks.

The estimated GARCH coefficient of KMI-30 ($\beta_1 = 0.377109$) is also positive and statistically significant at 5% level ($p = 0.0231$), indicating that the effect of volatility is not instantaneous but will persist for the next period. The level of persistence is moderate, but the result suggests that investors are cautious for a while when uncertainty levels rise, before confidence is regained. It is a normal phenomenon in emerging markets such as Pakistan, where financial markets are more sensitive to economic and political uncertainties than the developed markets.

The gold market is not statistically significant in terms of volatility dynamics within the estimated model as compared to the Islamic stock market. The mean is positive but not especially significant ($\mu = 0.00186$ with $p = 0.0711$) for gold returns. The ARCH ($\alpha_1 = 0.113104$ with $p = 0.0592$) and GARCH ($\beta_1 = 0.761545$ with $p = 0.0570$) coefficients are also not statistically significant. This indicates that the volatility regime did not significantly change over the sample period when the international gold price is considered. The result from Pakistan side suggests that gold did not play a major role as Islamic stock market volatility driver since its primary function is still as a store of value. When investors are looking to preserve their wealth in times of uncertainty, they may choose to invest in gold, but a trend in gold prices does not seem to cause immediate volatility in the returns of KMI-30. This is in line with the results of Baur and Lucey (2010) and the results of Chkili (2022) which found that gold serves as a safe-haven or diversification asset, rather than a significant driver of equity market volatility.

A different picture emerges for the oil market. Although the average return ($\mu = 0.00102$: $p = 0.6099$) is statistically insignificant, but both the ARCH ($\alpha_1 = 0.169847$: $p = 0.0015$) and GARCH ($\beta_1 = 0.660863$: $p = 0.0000$) parameters are positive and highly significant at 1% level of significance. These estimates suggest very rapid transmission and long-lasting effects of oil price shocks. This is a very economic phenomenon for Pakistan as it imports a considerable share of its energy needs. The higher costs of international crude oil prices lead to the increase in transportation and production expenses, intensifying the inflationary pressures, decreasing corporate profitability and consequently investor confidence. As a result, the oil market uncertainty is also emerging as a major risk for the Islamic equity market in Pakistan. Adekoya et al., 2022, Ali et al., 2022, and Bhatti et al., 2023, also found that oil price volatility is a major factor in the fluctuation of the stock market, especially in oil importing economies.

The Dynamic Conditional Correlation estimates add to the evidence on the interaction of the three markets. The estimated value of DCC alpha is essentially zero and statistically insignificant

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(p = 0.9997), meaning that unforeseen short term shocks do not immediately affect the correlation structure between KMI-30, gold and oil. Instead, the linkages between these markets do not change instantly based on new information, but rather change over time.

DCC beta coefficient, on the other hand, is positive and significant (β = 0.906784: p=0.000) which shows the strong persistence of conditional correlations. Once a change in the relationship between the Islamic stock market and commodity market, it will stay at that level for a long time, and will gradually come back to the level of equilibrium. The implications of this result are significant for Pakistan as a prolonged period of inflation, exchange rate instability and energy price shocks tend to generate a sustained period of uncertainty and not just a temporary shock in the short run. When that happens, the advantages of a short-term portfolio diversification strategy could be reduced because of the growing integration of financial and commodity markets. Engle (2002), Chkili (2022), and Sahabuddin et al., (2023) have also highlighted evidence of ongoing dynamic correlations.

The results of the DCC-GARCH estimates indicate that the overall volatility dynamics in Pakistan's Islamic stock market is influenced mainly by its own dynamics and developments in the international oil market, while gold has a relatively limited effect on the transmission of volatility. More importantly, the highly persistent dynamic correlation suggests that the relationship between KMI-30, gold and oil is not constant but varies over time in response to the changing economic conditions. This finding is helpful for investors that they should consider dynamic portfolio and risk management strategies instead of static diversification strategies for investing in Pakistan's Islamic capital market.

Robustness Analysis Using the ADCC-GARCH Model

The DCC-GARCH model is able to describe time-varying correlations under a symmetric scenario, but fails to consider the potential difference in how positive and negative shocks impact on correlations. An additional robustness test was performed by estimating the Asymmetric Dynamic Conditional Correlation (ADCC-GARCH) model put forward by Cappiello et al., (2006) to allow for asymmetry. The insignificant asymmetry parameter (γ) as a robustness check shows that the dynamic correlations are symmetric, reinforcing the results from the standard DCC-GARCH framework.

Table 8 Robustness Analysis: ADCC-GARCH Estimation Results

Parameter	Estimate	Std. Error	t-value	p-value
dcca1 (α)	0.0000	0.0106	0.0000	1.000
dccb1 (β)	0.9214***	0.1313	7.0167	0.000
dccg1 (γ)	0.0000	0.0139	0.0000	1.000

Source: Author's estimation using ADCC-GARCH model. Using R.Studio
Note: *** represents the magnitude of significance at 1% level

The results from Asymmetric Dynamic Conditional Correlation (ADCC-GARCH) model, estimated as a robustness check analysis, are included in Table 8 to verify if the dynamic correlations established from DCC-GARCH model are influenced by asymmetric shocks. The ADCC specification is an extension of the standard DCC model that introduces another asymmetry pa-

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rameter (γ) to analyze if there are differences between the effects of negative and positive shocks on dynamic correlations.

In ADCC-GARCH model, the ADCC alpha parameter (α = 0.0000) statistically insignificant (p = 1.000) consistent with the results reported in the DCC-GARCH model, the DCC alpha parameter (α = 0.0000) remains statistically insignificant (p = 1.000). This result reinforces the understanding that short-term innovations in the market do not bring about an immediate shift in the conditional correlations between a KMI-30 index, gold market and oil market. The fact that dcca1 (α) estimates are similar between the two models suggests that the correlation structure among the selected assets is not created by short-term market shocks, but changes over time.

Likewise, the ADCC beta parameter (β = 0.9214) is positive and highly significant with p< 0.01 and its value is a bit larger than that of the standard DCC-GARCH model (β = 0.9068). This outcome is a further confirmation of the previous finding that the dynamic correlations between the three markets are very persistent. After the degree of interdependence between the share market, gold, and oil changes, it tends to stay at this level for a long period of time before slowly returning to its long run equilibrium level. From a Pakistani point of view, this is a logical relationship as external shocks, in general, affect investor behavior over a long period of time, not just giving short-term reactions to the market. Engle (2002) and Chkili (2022) have found similar evidence for the persistence of dynamic correlations.

The value of the additional asymmetry parameter (γ = 0.0000) is statistically insignificant (p = 1.000), suggesting that negative shocks do not create a larger dynamic correlation than do positive shocks. Finally, the conditional correlations of KMI-30 with gold and oil are still symmetric after controlling for volatility persistence. This result implies that the correlation structure is not affected by adverse economic events like the rise in oil prices or by uncertainty in the markets differently from favorable ones. Thus, the dependence structure between the chosen markets seems to be well accounted for by the standard DCC-GARCH model.

The results from the ADCC-GARCH estimates confirm the results from the standard DCC-GARCH model. The dynamic correlations between the KMI-30 index, gold and oil are always high persistence in both models, and with no significant short-run or asymmetric relationship. The stability of the results holds the estimated correlation dynamics to be robust, allowing for more confidence in the analysis of volatility spillovers, hedging effectiveness and portfolio diversification that follows.

Volatility Spillover Matrix

Table 9 Volatility Spillover Matrix

Receiving Market	KMI-30	Gold	Oil	FROM
KMI-30	87.82	6.85	5.33	12.18
Gold	3.89	91.00	5.11	9.00
Oil	5.92	5.38	88.69	11.31

Source: Author calculation spillover analysis results using R.Studio

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Table 9 shows the volatility spillover matrix estimated in the Diebold–Yilmaz connectedness framework. The diagonal elements represent the share of volatility explained by the shocks of the respective market (own variance share), while the off-diagonal elements denote the transmission of volatility from one market to another. The last column (FROM) shows the total volatility that each market received from the other markets.

The results reveal that 87.82% of the forecast error variance is attributed to the KMI-30 Islamic stock market and the remaining 12.18% of the volatility comes from external markets. In particular, 6.85% and 5.33% of the variance is transmitted from the gold market and the oil market, respectively. The results of this study indicated that external commodity markets have a minor impact on Pakistan's Islamic stock market as compared to domestic factors driving the volatility of the stock markets. Changes in economic conditions, including monetary policy, inflation, political news, corporate results and investor confidence seem to be more significant than international variation in prices for gold and oil. However, the role of external markets cannot be ignored as it shows that some moderate risk is still being carried by the global commodity markets to the Islamic stock market in Pakistan. The findings are corroborated by Bhatti et al., (2023) and Aziz and Hussain (2021) who found that domestic market conditions remain the primary source of volatility in Pakistan's stock market despite increasing global financial integration.

The gold market has 91.00% of its volatility and 9.00% from other markets. The external contributors are KMI-30 index and the oil market, with 3.89% and 5.11% respectively. The high own variance share suggests that gold prices are not influenced by movements in the Islamic equity market in Pakistan and are instead driven by the influence of the international equity market, which is linked to the global economy and geopolitical changes, inflationary expectations, and policies of the central bank. Overall, gold has a relatively independent volatility structure, reinforcing its traditional diversification, safe-haven asset qualities. The result is similar with Baur and Lucey (2010) and Chkili (2022), who found that overall, the gold market tends to be less connected with equity markets, especially during periods of greater uncertainty.

Likewise, the oil market accounts for 88.69% of the volatility of the oil market and the remaining 11.31% is transmitted from the KMI-30 and gold markets. The KMI-30 accounts for 5.92% of oil market volatility while gold accounts for 5.38%. These findings imply that the world supply demand situation, geopolitical events, OPEC production decisions, and international economic activity are the key factors influencing world oil prices. However, the moderate spillovers from the Islamic stock market and gold indicate that financial market conditions also contribute to oil price dynamics. This finding is an economically important for Pakistan as the country is highly vulnerable to external energy shocks due to its dependence on imported crude oil. Ali et al., (2022) and Adekoya et al., (2022) also recorded similar trend, still, oil markets are self-driven but continue to exchange volatility with financial markets.

All three markets are driven mostly by their own shocks, as evidenced in the spillover matrix, and have own variance shares. While there is cross-market volatility transmission, it is not very large. This means that the market of the KMI-30, gold, and oil markets are relatively independent and offer the opportunity to diversify a portfolio. Concurrently, the spillovers on external commodity markets are not zero, which suggests the role of external commodity markets in determining the risk of the Islamic stock markets in Pakistan cannot be neglected. These results form

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the foundation for the next stage of the analysis, which determines the directional spillovers and their nature (transmitter or receiver) in the volatile connectedness system.

Table 10 Directional and Net Spillover Measures

Market	TO Others	FROM Others	NET Spillover
KMI-30	9.81	12.18	-2.37
Gold	12.23	9.00	3.23
Oil	10.45	11.31	-0.86

Total Connectedness Index (TCI) = 10.83%

Table 10 shows the Diebold–Yilmaz (2014) connectedness measures of direction and net volatility spillover. The "TO Others" column indicates the effect that each market has on the other markets, while the "FROM Others" column shows how much volatility each market receives from the other markets. The difference between these two measures is the Net Spillover, reflecting the net transmission or net receiver of volatility in a market.

The results indicate that the KMI-30 Islamic stock market transmits 9.81% of its volatility to the gold and oil markets while receiving 12.18% from them, resulting in a net spillover of –2.37%.. The negative net spillover indicates the KMI-30 index is a net receiver of volatility from the interconnected system. This finding implies that Pakistan's Islamic stock market is more vulnerable to external shocks than it is influential in transmitting risk to commodity markets. The impact of external macroeconomic conditions, fluctuations in international commodity prices and global financial uncertainty are more likely to affect the domestic equity market volatility as compared to the other way around, due to Pakistan's emerging economy and being an oil importing economy. The result is in line with the findings obtained by Aziz and Hussain (2021) and Bhatti et al., (2023), which emphasized that the stock market in Pakistan is sensitive towards the developments in external commodity markets.

The gold market transmits 12.23% of volatility to the other markets while receiving only 9.00% and producing a positive net spillover of 3.23%. This positive value identifies gold as the largest net transmitter of volatility among the three markets. From an economic perspective, it confirms that gold remains the primary financial asset traded internationally and that its price changes quickly as a reaction to changes in the global economic environment, inflationary risk and geopolitical uncertainty. Shocks originating in the gold market are more likely to influence Pakistan’s Islamic stock market than the reverse, as gold prices are primarily determined by conditions in international markets. The results corroborate with Baur and Lucey (2010) and Chkili (2022) who suggested that gold fulfills an important role in conveying information across financial markets and also acts as a safe-haven asset during market stress.

The oil market transmits 10.45% of volatility and receives 11.31%, resulting in a net spillover of –0.86%. Although the magnitude is relatively small, the negative value indicates that oil acts as a net receiver of volatility in the connectedness network. The magnitude is not large but its negative value suggests that the oil sector can be considered as a net receiver of volatility in the overall network of connectedness. From this finding, it shows that international oil prices have a significant effect on the economy of Pakistan and the fluctuations in the oil market during the sam-

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pled period are also influenced by the other markets such as Islamic stock market and gold market. However, the spillover system is relatively well-balanced in terms of transmissions and receipts, suggesting that oil occupies an intermediate position within the spillover system. Ali et al., (2022) and Adekoya et al., (2022) found evidence of oil market to financial market (bidirectional) volatility transmission in emerging markets.

The Total Connectedness Index (TCI) is estimated to be 10.83%, meaning that 89.17% of the total forecast error variance is due to market-specific shocks, with the remaining 10.83% coming from cross-market spillovers. The relatively low connectedness implies that the KMI-30, gold and oil markets have significant independence even though there is measurable volatility transmission. In Pakistan's context, the low amount of interdependence means that investors can continue to diversify their portfolios even with a low level of interdependence by allocating a portion of their funds to real assets, like gold, because shocks do not travel strongly among the three markets. Considerable moderate connectedness is found in studies related to the equity market and Islamic commodities markets conducted by Sahabuddin et al., (2023), who found that the degree of market integration is not strong, even if there is an increase in the volatility spillovers during the economic uncertain period.

Using directional spillover analysis, it is found that volatility in gold is the main transmitter, while the KMI-30 Islamic stock market is the largest receiver of external shocks, and the oil market having an intermediate position. In addition, the overall connectedness Index (10.83%) implies that transmission of volatility among the selected markets is moderate, which means that there are good diversification opportunities for investors in Pakistan. The results also correspond well with the earlier DCC-GARCH results, suggesting that the market interconnectedness of the KMI-30 index, gold, and oil markets have not changed significantly in the short-run, but rather the dynamic correlations have remained.

Dynamic Correlation Graphs

Dynamic Correlation between KMI-30 and Gold

The dynamic conditional correlation between KMI-30 Index returns and gold returns for 2016–2025 is shown in figure A2. It is seen from the results that the correlation experienced an overall low and stable level during the sample period, with some fluctuations appearing during the economic and financial uncertainty period. The negative correlation is not very strong, indicating that the movements of gold and the Islamic stock market are largely independent.

The pattern observed suggests that the growth of the gold market have only small effects on the behavior of KMI-30 returns. The result confirms the results of studies by Baur and Lucey (2010), Reboredo (2013), and Chang et al., (2015) that showed gold's performance as a hedge and safe-haven asset in markets under stress and uncertainty.

When it comes to investment, the low and stable dynamic correlation indicates that when investing in Islamic equities, gold can be combined with those equities to offer diversification benefits. The correlation between the two assets do not change significantly over time, and investors can help lower the risks of their portfolios by adding gold to their Islamic stocks. Thus, it can be argued that gold is a good hedging tool for the stock market volatility in Pakistan on the basis of the results.

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Dynamic Correlation between KMI-30 and Oil

The dynamic conditional correlation between the returns of KMI-30 and crude oil returns has been shown in figure A3 for the sample period. The correlation between Islamic stock market and crude oil has been observed to shift considerably throughout the period, unlike the relatively stable correlation between KMI-30 and gold. The changes in the correlation suggest that there is a dynamic relationship between the two markets, where some strong increases in the correlation took place during times of economic uncertainty and global financial stress. The movements indicate that the oil development has a significant effect on the characteristics of Pakistan Islamic Stock Exchange.

The correlation pattern is also changing, which further suggests that the oil price-KMI-30 correlation is not stable over time. Rather, the relationship is determined by market conditions and external economic events. It means that investors and portfolio managers should pay attention to oil market developments when deciding what to invest in or allocate to different portfolios. Other studies, like Mensi et al., (2017) and Ghallabi et al., (2024), have also reported that commodity markets and stock markets are significantly correlated over time, notably during uncertain times.

Conditional Volatility Graphs

The conditional volatility series of KMI-30 returns, gold returns, and crude oil returns is displayed in figure A4. In all three markets, there is clearly volatility clustering, with high volatility periods followed by additional high volatility periods and while relatively lower periods tend to be followed by lower market fluctuations. This pattern indicates that volatility is not stable over time and tends to persist once it emerges.

Among the selected assets, crude oil exhibits the highest level of volatility, indicating that the oil market experienced greater uncertainty and larger price fluctuations during the sample period. In comparison, gold displays relatively lower volatility, highlighting its more stable behavior and supporting its role as a defensive investment asset. The KMI-30 Index shows a moderate level of volatility, falling between gold and oil in terms of market fluctuations.

However, there are a few noticeable spikes in volatility which can also be seen at times of major economic and financial turmoil. The sharp increase is due to the impact of external shocks and the increased uncertainty of financial markets. Similar patterns of volatility clustering and persistent market fluctuations has been documented by Bollerslev (1986), and Mensi et al., (2017).

Net Spillover and Connectedness Graphs

Figure A5 provides transmission of volatility spillovers between the KMI-30, gold and oil markets. The graphs illustrate that gold is a net shock transmitter to other markets, and it is more volatile than others. On the contrary, KMI-30 seems to be a net receiver of volatility suggesting that the Islamic stock market seems more sensitive to developments in the gold and oil markets. This pattern indicates that external market conditions have a significant impact on the volatility of the Islamic equity market in Pakistan. Agrawal and Kumar (2025) and Ghallabi et al., (2024) have reported similar spillovers.

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Figure A6 displays the Total Connectedness Index (TCI), which shows that the assets in this sample are moderately interconnected. Although volatility spillovers are present but markets are not fully integrated. This is significant in terms of investment as it suggests that there are still opportunities for diversification within the assets chosen. It is also shown that connectedness varies through time and is not constant. The spillover effects are more pronounced during periods of higher market stress and economic uncertainty, suggesting greater linkages between financial and commodity markets during times of turmoil.

Conclusion

The present study investigates the volatility spillover effect between real assets and the Islamic stock market in Pakistan through investigating the relationship between returns of KMI-30 index crude oil returns, and gold returns during the period 2016–2025. To achieve this objective, a combination of descriptive statistics, unit root testing, the EGARCH model, the DCC-GARCH framework, and the Diebold-Yilmaz spillover approach was employed. These methods enabled them to evaluate volatility persistence, shifting market correlations, and connectedness between the selected markets.

The findings indicate that volatility continues to be one of the key characteristics of the Islamic stock market and the oil market. The results of the EGARCH model show that over the years, oil price fluctuations have a significant effect on the volatility of KMI-30 returns. The result is consistent with the Sadorsky (2012) who also noted that uncertainty in oil markets can affect investor expectations and the behavior of the stock market. International oil price fluctuations have a direct impact on production costs, inflationary pressures, business activity, and corporate earnings which in turn, can impact investor confidence and the stock market.

While gold did not have a significant direct effect on the volatility of the Islamic stock markets, spillover analysis reveals that it is a net transmitter of volatility in the interconnected network. It is broadly consistent with the results obtained by Baur and Lucey (2010) and Reboredo (2013) who pointed out gold's role as a hedge and safe-haven asset in times of uncertainty. The inability to find the direct correlation between gold and the Islamic stock market due to the different nature of gold investment. In economic uncertainty, investors may shift some funds from other assets to gold, an asset that is considered a store of value and a safeguard of purchasing power. As a result, gold tends to follow a different pattern from equity markets, limiting the degree of direct integration between the two assets.

The findings indicate that the gold and oil returns have different impact on Islamic stock market in Pakistan. The influence of the oil price seems to have more impact on the volatility of the returns of KMI-30 while the gold exhibits more independent role within the network of connectedness. This means that oil market shocks have greater tendency to impact investor behavior and market conditions in Pakistan. Gold, however, remains a diversification tool, especially in uncertain economic and financial periods. These observations are found to be similar to the theoretical framework of Engle (2002) and empirical evidence given by Sahabuddin et al., (2023).

The DCC-GARCH results indicate that the correlation between the KMI-30 index and the other variables are dynamic but very persistent this implies that the extent of market interdependence

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varies over time but not necessarily in response to short-term shocks. The robustness analysis performed with the ADCC-GARCH model also verifies that the asymmetric correlation parameter is not statistically significant, that negative shocks do not affect the correlation structure in a different way as compared to positive shocks. Hence, the standard DCC-GARCH model adequately captures the dynamic dependence among the selected markets, supporting the robustness of the estimated correlation dynamics.

The spillover analysis in this study reveals that there is a moderate level of market connectedness (TCI of 10.83%), which suggests that the majority of the volatility stems from market specific factors and not from cross market transmissions. Gold comes out as the highest net transmitter of volatility while the KMI-30 index comes out as the highest net receiver of volatility, showing that the Islamic stock market in Pakistan is exposed to the external commodity market fluctuations more than others. The relatively low connectedness is also broadly reflected in the work of previous studies on financial markets of Bhatti et al., (2023) and Baur & Lucey (2010), while showing meaningful diversification potential for investors who diversify across the Islamic equities and real assets such as gold.

This study contributes to the growing literature on Islamic finance and commodity market connectedness by providing evidence from Pakistan's Islamic stock market. The study focuses on analyzing the interaction between KMI-30, gold and oil returns within a long timeframe which contributes to understanding of the transmission of volatility, market interconnectedness and diversification opportunities in an emerging economy. The findings can assist investors, portfolio managers and policy makers in their decision-making processes for managing risk and allocating portfolios.

Practical Implications

Results from this study have implications for participants and policy makers. Given the relatively low correlation between KMI-30, gold and oil, it could be valuable to consider diversifying with these assets in the same investment portfolio. Gold in particular seems to be its traditional role as a defensive asset, particularly in times of greater economic and financial uncertainty. This result is significant in the case of Pakistan, as gold is considered as a safe investment during economic volatility and currency fluctuations. Thus, the addition of gold along with Islamic equities could be beneficial for portfolio diversification and better risk management.

The results have implications for portfolio managers. They should keep an eye on global oil market developments when deciding on their investment strategy. Given that the price of oil has a significant impact on the volatility of the Islamic stock market, it is important to take into account changes in energy markets in portfolio risk management and asset allocation strategies for the stock market. The time-invariant correlations also indicate that market relationships are not static and that relying on fixed-value assumptions and projections to guide investment strategies may be less effective. The results also carry important implications for policymakers and financial regulators. Pakistan is heavily reliant on imported energy resources and oil price volatility can have a significant impact on investor confidence, market stability, and economic conditions. Therefore, strengthening market resilience and closely monitoring external commodity market developments may help reduce the impact of future shocks.

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The moderate level of connectedness among KMI-30, gold, and oil indicates that diversification opportunities remain available. Consequently, investors may consider a strategy of diversifying their portfolios by holding both Islamic equities and real assets in order to manage risk and diversify more effectively.

Future Research Recommendations.

This research has several limitations as with any empirical research. The study only analyzed real assets, which were gold and oil, and used weekly data of the sample period (2016–2025). Therefore, the results are to be considered in the context of the variables and time period chosen. Further studies could expand the analysis to include other macroeconomic variables including exchange rate, inflation, interest rates, and the geopolitical risk indicators as these variables could also affect the behavior of Islamic stock markets.

In addition, the study is based on weekly data, which may not fully reflect short-term market movements. Future research can take advantage of daily data to better reflect the time-varying volatility and dynamic market interactions. The use of higher-frequency data could provide a more comprehensive understanding of volatility spillovers and connectedness among financial markets. A useful extension would be a comparison of the Islamic stock markets and conventional stock markets for Pakistan to determine whether the transmission of volatility and market connectedness differs across the two financial systems.

Furthermore, future studies could integrate traditional volatility models with more sophisticated machine learning algorithms, such as Long Short-Term Memory (LSTM) networks or Transformer-based forecasting models, for a comparison of the predictive power of both models and for more precise volatility forecasting.

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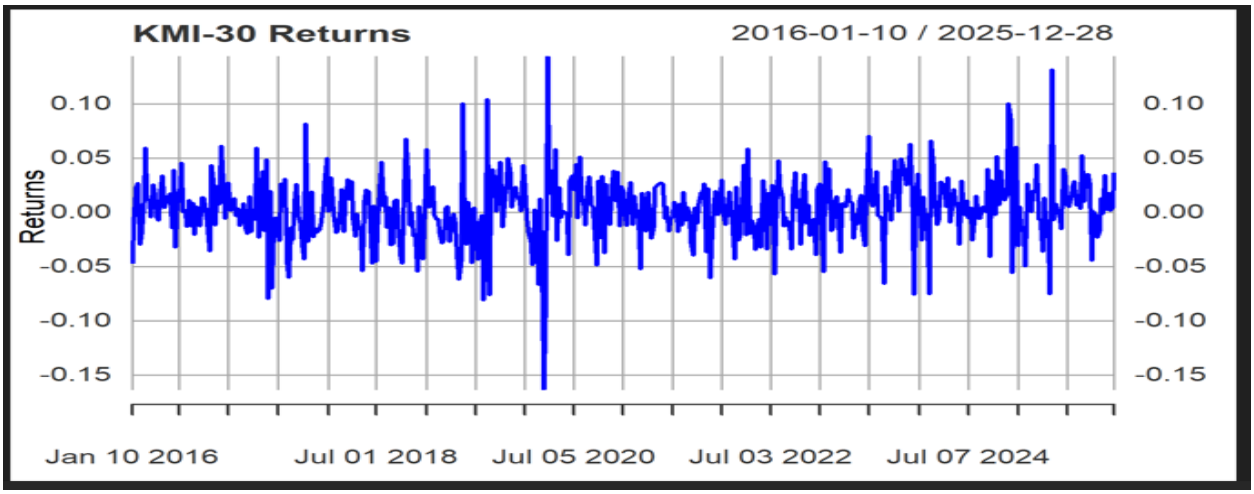
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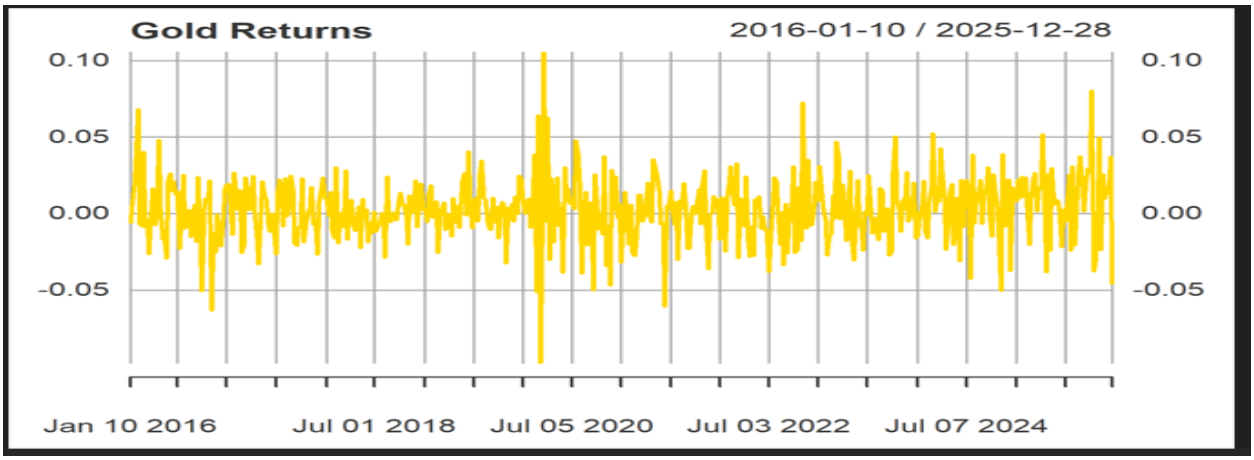
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Appendix

Figure A1. KMI-30, Gold and Oil Price Returns Graphs



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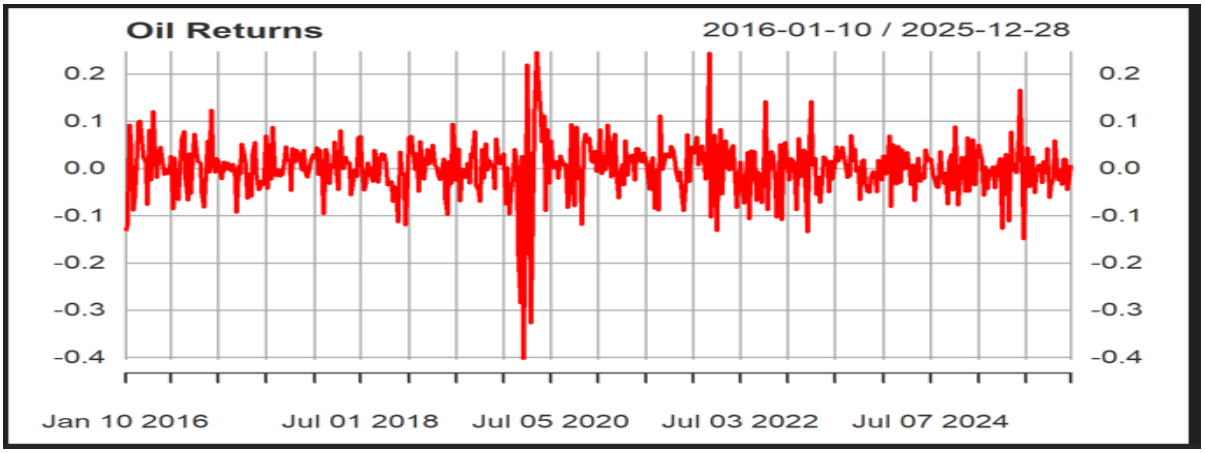
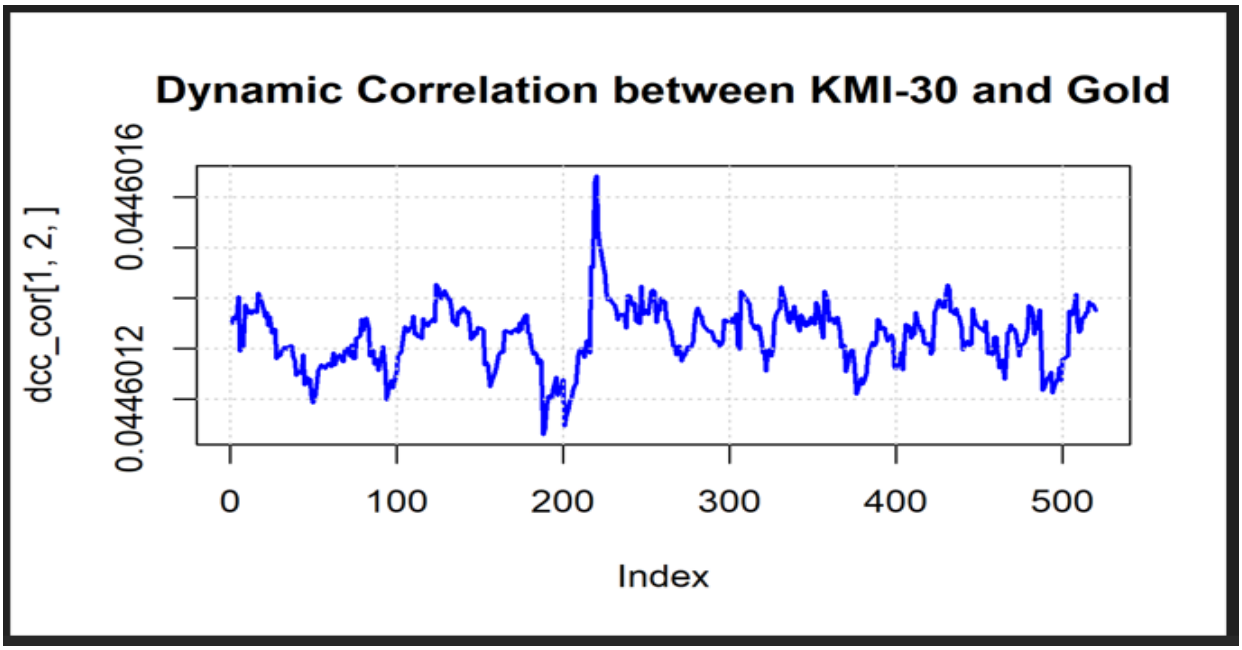


Figure A2. Dynamic Correlation between KMI-30 and Gold



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Figure A3. Dynamic Correlation between KMI-30 and Oil

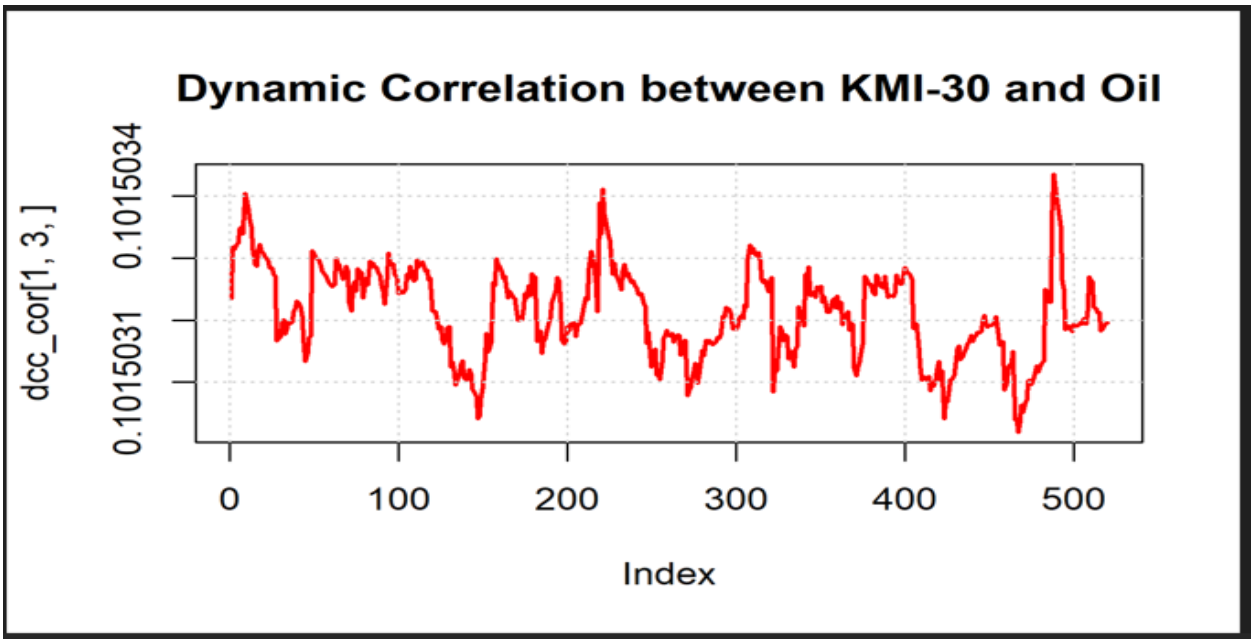


Figure A4. Conditional Volatility Graphs

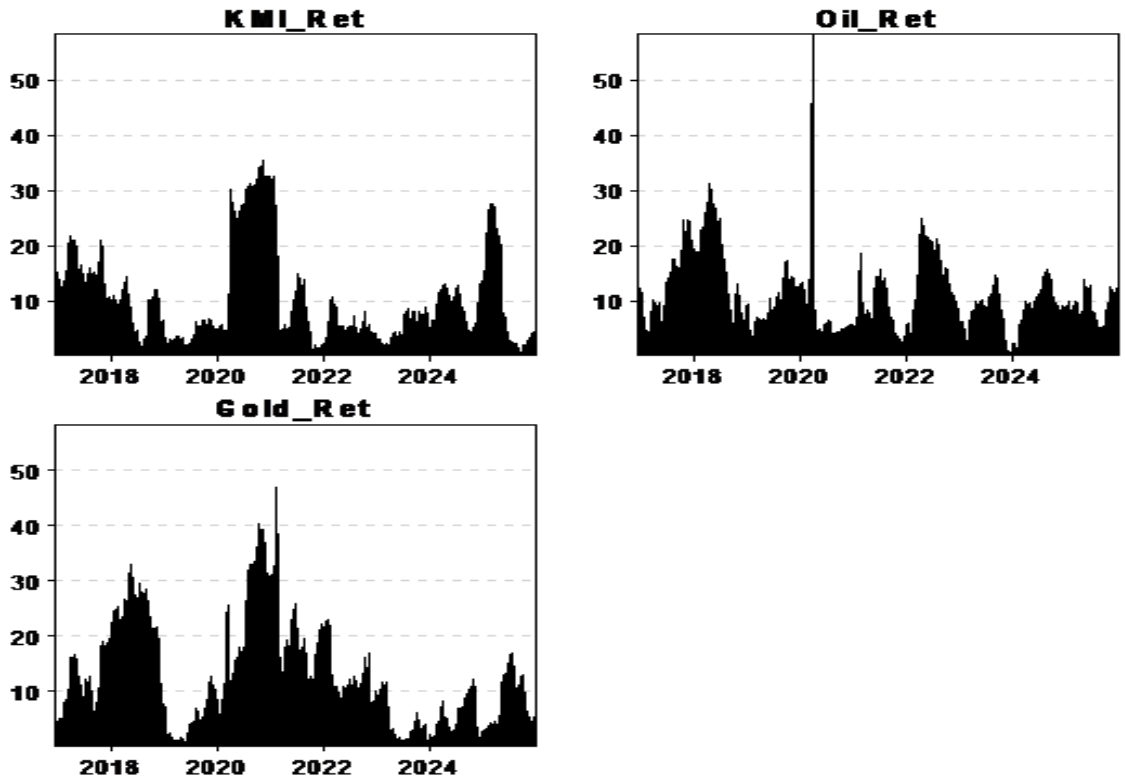


Figure A5. Net Spillover

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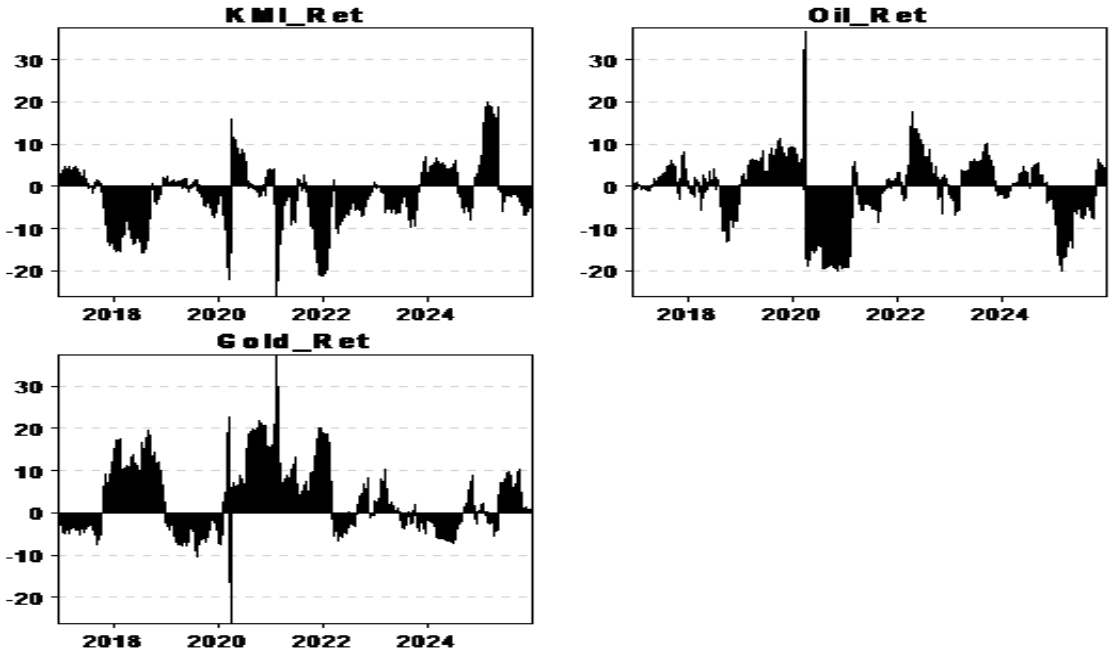


Figure A6. Connectedness Graphs

