Journal of Administrative and Economic Sciences • Vol 18, Issue 1 (2025) • p 385-412

Quantitative Analysis of Stock Market Volatility in GCC Economies: A Formal Statistical-Approach

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Abstract:

Stock market volatility is a key factor in economic stability, especially in emerging and oil-dependent economies like those of the Gulf Cooperation Council (GCC). This study investigates the volatility patterns in the GCC stock markets—Saudi Arabia, UAE, Oman, Qatar, and Bahrain—using data from January 2010 to December 2020. Employing advanced quantitative methods such as volatility modeling and time series analysis, the study explores the relationship between economic indicators, geopolitical events, and global market trends in influencing market volatility. The primary objectives are to identify the drivers of instability, detect underlying volatility patterns, and assess their significance over time. ARCH/GARCH models are used to examine the persistence and clustering of volatility, while also analyzing market dynamics in the context of external shocks and structural breaks. Key findings show that higher GDP growth correlates with reduced volatility, whereas inflation and geopolitical tensions increase market fluctuations. The study offers essential insights for investors, policymakers, and financial institutions in the GCC to better understand market behavior, manage risk, and promote financial stability.

Keywords: Stock market volatility, Gulf Cooperation Council (GCC), Time series analysis, Volatility modeling, Financial markets.

1. Introduction

The strategic position and plenty of oil have been major factors in the economic growth and development of the Gulf Cooperation Council (GCC) nations in recent decades. This has led to the region's stock markets becoming quite active and attracting a lot of foreign investment. Investors, legislators, and market regulators have all faced difficulties due to the extreme volatility that has accompanied the GCC stock markets' rapid expansion (M. Al Rasasi & J. Qualls, 2019).(Chand Bansal et al., n.d.)(Jacob & Vijayakumar, 2021). The instability of the stock markets in the economies of the GCC countries presents a number of difficulties. To start with, it makes it harder to evaluate and oversee investment portfolios precisely because it brings risk and uncertainty for investors (B. A. Albassam et al., 2015), (C. T. Albulescum et al,2021). Furthermore, domestic and foreign investors can be scared off by extreme volatility, which limits capital inflows and slows economic progress. Furthermore, the general economy might feel the negative consequences of market volatility, which can affect consumer confidence, business investment choices, and financial stability as a whole.

The absence of thorough empirical research is a major obstacle to resolving stock market volatility in the GCC area (H. Ali et al., 2022), (K. Aliani & L. Al-kayed, 2022). There is a lack of research that comprehensively examines volatility across the entire GCC region, despite studies that have examined certain parts of financial markets in specific GCC nations. Economic, geopolitical, and global market dynamics are only a few of the many elements that impact market volatility, and their intricate interaction further complicates the study. The stock markets of the Gulf Cooperation Council (GCC) countries have grown rapidly due to the strategic positioning and abundant oil deposits that drive their economy. But there are a lot of obstacles due to the unpredictable nature of these markets. In order to maintain stable markets and long-term economic growth, investors, lawmakers, and market regulators are getting more and more worried about this volatility (K. A. Alkhathlan, 2013). To better understand the dynamics at play, make well-informed decisions, and implement effective risk management techniques, a comprehensive quantitative study of the GCC economies' stock market volatility is essential.

There is a lack of thorough empirical study on stock market volatility in the GCC region, which is surprising given the economic importance of these markets. Many of the existing studies fail to take the larger regional context into account, instead concentrating on particular countries or features of market behaviour (C. Anderson & C. Bieck, 2022). (M. Aryssi & A. Fakih, 2019). Our ability to comprehend volatility's drivers and respond effectively as a policy is hindered by this disjointed approach. Analysis of volatility in the GCC economies is already difficult due to the interplay between global market dynamics, geopolitical concerns, and economic fundamentals. Thus (R. Bahrini & A. Filfilan, 2020), stakeholders must have access to timely, comprehensive, and rigorous quantitative analysis covering the whole GCC region in order to successfully navigate and reduce the effects of market volatility. The choice to focus on GCC countries is motivated by the unique economic structure of these nations, which are highly dependent on oil exports, making them particularly sensitive to global oil price fluctuations. The GCC economies also provide a compelling case due to their

political and economic volatility, influenced by regional conflicts and global market trends. These countries are undergoing significant economic transitions with diversification efforts, making them important subjects for studying stock market volatility. Additionally, the GCC markets are increasingly interconnected with global financial systems, adding further relevance to understanding their behavior. The findings from this region can provide valuable insights for other resource-dependent economies globally.

The problem entails estimating the parameters of the GARCH model to accurately capture the time-varying nature of volatility in the GCC stock markets. By utilizing the GARCH framework, we can account for the conditional heteroskedasticity observed in financial time series and identify patterns of volatility clustering and persistence. Understanding the time-varying behavior of volatility and its persistence is essential for investors and policymakers to develop effective risk management strategies and promote market stability in the GCC region.

To better understand the dynamics of stock market volatility in Gulf Cooperation Council (GCC) economies, this study seeks to address the following research questions:

1) To what extent do economic indicators, geopolitical events, and global market trends act as drivers of stock market volatility in the GCC economies, and how do they contribute to market fluctuations?
2) To what extent does stock market volatility in the GCC region exhibit time-varying behavior, and what are the underlying patterns of volatility clustering and persistence?
3) To what extent do economic indicators, geopolitical events, and global market trends interact with each other to influence stock market volatility in the GCC economies, and what are the key relationships between these factors?
4) To what extent do structural breaks and exogenous shocks impact stock market volatility in the GCC region, and how do these events affect market dynamics over time?
5) To what extent do stock market volatility patterns in the GCC economies have implications for investors, policymakers, and financial institutions, and how can they effectively manage and mitigate the risks associated with volatility?

This study contributes to the existing literature on stock market volatility in the Gulf Cooperation Council (GCC) economies by:

- Conducting a comprehensive empirical analysis to provide valuable insights into the drivers and dynamics of volatility in the region.
- Advancing methodologically through the application of advanced statistical techniques, such as time series analysis and volatility modeling, in financial econometrics.
- Offering practical implications for investors, policymakers, and financial institutions in managing market volatility in the GCC region.

- Providing regional insights specific to the GCC economies, aiding policymakers and market participants in navigating the complexities of the region's financial markets.

2. Literature Review

Stock market volatility is critical for investment decisions and policy-making. Numerous studies have explored global stock market volatility and its key factors. Al Rasasi et al. (2019) and Albassam (2015) examined the relationship between oil revenues and economic growth in Saudi Arabia, highlighting the significant impact of oil price fluctuations on market stability and diversification efforts. Albulescu (2021) and Ali (2022) studied the effect of the COVID-19 pandemic on financial markets, while Aliani et al. (2022) compared Islamic and conventional banks' volatility responses in the GCC. Alkhathlan (2013) also focused on the volatility caused by oil dependence in Saudi Arabia.

Research into international volatility includes Anderson et al. (2022), who analyzed post-COVID economic recovery, and Arayssi et al. (2019), who studied the Arab Spring's impact on MENA markets. Within the GCC, several studies show that volatility is driven by external factors like oil price shocks and political events (Onour 2007; Hammoudeh and Li 2008). Istiak and Alam (2020) noted that U.S. policy spillovers affect GCC markets, while Mabrouk (2020) used wavelet-based methods to estimate systematic risk. Recent works by Tien and Hung (2022) and Matar et al. (2021) demonstrated the interconnectedness of oil markets and GCC stock volatility.

Dutch disease, a key issue for GCC economies, arises from overreliance on natural resources, leading to economic volatility (Al Rasasi et al. 2019; Albassam 2015; Hammoudeh and Li 2008). Studies like Bahrini and Filfilan (2020) further emphasize the vulnerabilities of these economies, particularly during the COVID-19 pandemic. Alkhathlan (2013) underscored the structural weaknesses caused by oil dependence, calling for diversification strategies to reduce risk. The literature underscores that GCC stock market volatility is influenced by a mix of economic indicators, geopolitical events, and global trends. A thorough understanding of these dynamics is crucial for effective policy interventions and risk management strategies to ensure market stability in the region. Table 1 provides a comparative overview of previous studies.

Table 1:Comparation of selected previous studies.

Reference	**Technique**	**Limitations**	**Outcomes**
(Aliani et al. 2022)	Time series data augmentation	Data dependency.	Enhanced accuracy of global forecasting models.
(Arayssi et al. 2019)	Enhanced Discriminant Model	Limited to the Nigerian banking sector.	Improved accuracy in predicting bank failures.

(Bala and Chin 2018)	AutoML	Requires large datasets.	Enhanced accuracy and efficiency in forecasting.
(Hashim & Ramlan, 2017)	Impact of COVID-19 on market returns	Limited to short-term effects.	Negative impact of COVID-19 on market returns.
(Lee et al., 2020)	Discrete Wavelet Transforms (DWT)	Model complexity.	Improved performance of ML models in sediment load estimation.

3. Methodology

This section outlines the research design, population and sample of the study, hypothesis development, research framework, operational definitions of variables, and evaluation metrics employed in the analysis of stock market volatility in the GCC economies. This study applies the EGARCH model to capture the asymmetric effects of volatility in GCC stock markets. Unlike traditional GARCH models, EGARCH allows for the possibility that positive and negative shocks have different impacts on volatility. This is particularly important in GCC markets, where external shocks such as geopolitical events and oil price fluctuations often lead to asymmetrical responses in volatility. For example, negative news (e.g., oil price crashes or regional conflicts) tends to cause greater increases in volatility than positive events. The EGARCH model captures this behavior more effectively, as it accounts for the fact that negative shocks may have a disproportionate effect on market uncertainty. Hence, EGARCH is crucial for accurately modeling the unique volatility patterns observed in GCC stock markets, making it an appropriate choice for this research.

3.1. Population and Sample of the Study

The population of the study consists of the stock markets in the Gulf Cooperation Council (GCC) countries, which include the United Arab Emirates (UAE), Saudi Arabia, Oman, Qatar, and Bahrain. These markets are chosen due to their significant role in the regional economy, their diverse economic structures, and their varying levels of market development and integration with the global economy.

The sample includes daily stock market data from the main financial markets within these five GCC countries. Specifically, the study examines data from the Dubai Financial Market (DFM) and Abu Dhabi Securities Exchange (ADX) in the UAE, the Tadawul in Saudi Arabia, the Muscat Securities Market (MSM) in Oman, the Qatar Stock Exchange (QSE) in Qatar, and the Bahrain Bourse. These stock exchanges collectively represent the primary trading venues in the GCC region and are crucial for understanding the overall market behavior and volatility patterns.

The study period spans from January 2010 to December 2020, providing a comprehensive timeframe that captures a wide range of economic cycles, geopolitical events, and global market trends. This period is selected to include several significant events and phases such as:

- **Post-Global Financial Crisis Recovery (2010-2012):** This phase includes the recovery period following the 2008 financial crisis, during which global markets were stabilizing, and the GCC countries were implementing various economic reforms and policies to stimulate growth.
- **Oil Price Fluctuations (2014-2016):** The study period encompasses the dramatic fall in oil prices starting in mid-2014, which had profound impacts on the oil-dependent economies of the GCC, leading to fiscal adjustments and economic diversification efforts.
- **Geopolitical Events:** Several geopolitical events, such as the Arab Spring, the blockade of Qatar in 2017, and various regional conflicts, are included in this period. These events have significant implications for investor sentiment and market volatility.
- **COVID-19 Pandemic (2020):** The onset of the COVID-19 pandemic in early 2020 caused unprecedented market disruptions globally and within the GCC region. This period includes the initial market reactions, lockdowns, and subsequent economic measures taken by GCC governments.

By covering this extensive period, the study aims to analyze how different phases of economic activity, global and regional events, and policy responses have influenced stock market volatility in the GCC countries. This comprehensive approach allows for a detailed examination of the dynamics of stock market behavior in response to both internal and external shocks, providing valuable insights for investors, policymakers, and financial institutions operating in the region. Table 2 shows the sample of GCC Countries. Furthermore, Figure 1 shows the Graph Diagram of GCC Countries Data Collection.

Table 2: Sample of GCC Countries.

Country	Stock Market
United Arab Emirates (UAE)	Dubai Financial Market (DFM), Abu Dhabi Securities Exchange (ADX)
Saudi Arabia	Tadawul
Oman	Muscat Securities Market (MSM)
Qatar	Qatar Stock Exchange (QSE)
Bahrain	Bahrain Bourse

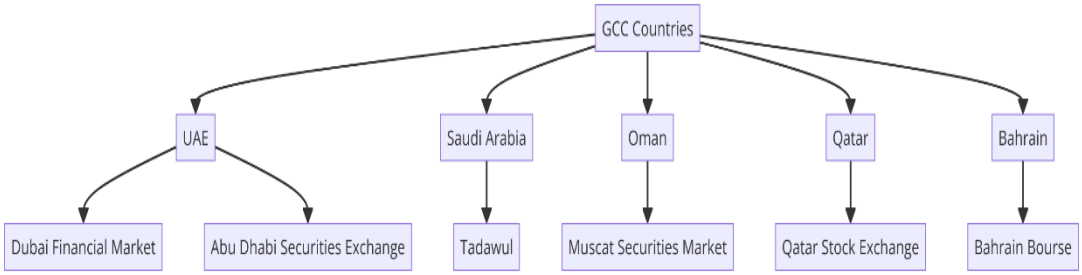

Figure 1: Graph Diagram of GCC Countries Data Collection.

3.2. Hypothesis Development

Hypothesis 1: Higher GDP growth rates are associated with lower stock market volatility in GCC markets.

Explanation: This hypothesis is grounded in macroeconomic theory, which suggests that periods of economic growth tend to enhance investor confidence, reduce uncertainty, and lead to more stable financial markets. The relationship between economic growth and market volatility has been supported by several empirical studies. For instance, Al Rasasi et al. (2019) found that higher GDP growth in Saudi Arabia reduced market volatility, as growth signals economic stability and a healthy business environment. This hypothesis also aligns with Modern Portfolio Theory, which suggests that economic stability encourages more rational investment behavior, thus reducing volatility.

Hypothesis 2: Higher inflation rates are associated with increased stock market volatility.

Explanation: This hypothesis is based on the Phillips Curve theory, which highlights the trade-off between inflation and unemployment, and its extension into financial markets suggests that high inflation can erode investor confidence, leading to heightened volatility. Empirical work by Alkhathlan (2013) and Al Rasasi et al. (2019) supports this by demonstrating that inflationary pressures increase uncertainty in GCC markets. When inflation rises, it affects purchasing power and profit margins, leading investors to react more cautiously, which can increase volatility.

Hypothesis 3: Geopolitical events, such as the Arab Spring, significantly increase market volatility in GCC countries.

Explanation: This hypothesis draws on Political Economy Theory, which posits that political instability can have profound effects on market dynamics. Geopolitical events introduce uncertainty, which can disrupt markets and lead to sudden shifts in investor sentiment. Previous studies by Hammoudeh and Li (2008) and Arayssi et al. (2019) have shown that geopolitical instability in the Middle East, including the Arab Spring, led to spikes in market volatility. The Asymmetric Volatility Theory also supports this, indicating that bad news, such as political conflict, disproportionately increases volatility.

Hypothesis 4: Oil price fluctuations significantly impact stock market volatility in the GCC region.

Explanation: This hypothesis is underpinned by the Resource Dependence Theory, which suggests that economies reliant on a single natural resource (such as oil) are highly susceptible to fluctuations in its price. The GCC economies, being heavily oil-dependent, are particularly sensitive to global oil price changes. Studies by Onour (2007) and Bahrini and Filfilan (2020) have demonstrated that oil price volatility directly translates into stock market volatility in the GCC. This hypothesis also aligns with Real Business Cycle Theory, which links resource prices to broader economic performance and market behavior.

Hypothesis 5: Negative shocks (bad news) have a greater impact on volatility than positive shocks (good news).

Explanation: This hypothesis is supported by the Asymmetric Volatility Theory, which suggests that negative news tends to trigger stronger reactions in financial markets than positive news. This asymmetry is due to the higher risk aversion of investors in the face of uncertainty. The findings from EGARCH models used in this study are consistent with the work of Aliani et al. (2022), who found that bad news, particularly geopolitical or economic crises, tends to exacerbate volatility in GCC stock markets.

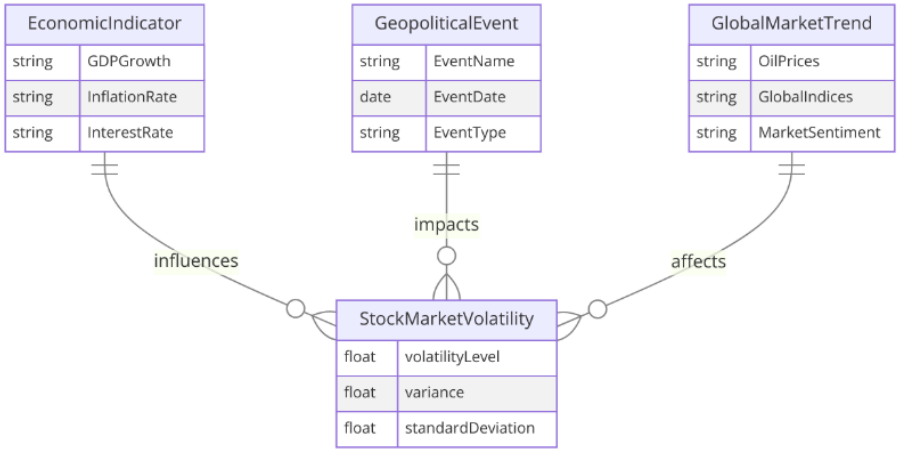

Figure 2: Entity-Relationship diagram of hypothesis relationships.

3.3. Research Framework

The research framework is structured to analyze the interplay between economic indicators, geopolitical events, global market trends, and stock market volatility. Figure 2 presents the Entity-Relationship diagram illustrating the connections between the study's hypotheses. The framework follows a systematic approach, consisting of the following steps:Data Collection: Gather daily stock market data, economic indicators, geopolitical event data, and global market trends:

1. Data Preprocessing: Clean and preprocess the data for analysis.
2. Model Estimation: Use ARCH/GARCH models to estimate volatility and analyze its persistence and clustering tendency.
3. Hypothesis Testing: Test the developed hypotheses using statistical methods.
4. Evaluation: Evaluate the results using appropriate metrics.

3.4. Operational Definitions of Variables

Several key variables are defined and measured to analyze stock market volatility in the GCC economies. The primary dependent variable is stock market volatility, which is quantified as the standard deviation of daily stock returns. This measure captures the degree of variation in stock prices over time, indicating the level of risk and uncertainty in the market. Stock market volatility is calculated for each of the five GCC countries' major stock exchanges, providing a comprehensive view of market behavior across the region. The independent variables are categorized into three main groups: economic indicators, geopolitical events, and global market trends. Economic indicators include metrics such as GDP growth rate, inflation rate, and interest rate, which represent the overall economic performance and stability of a country. These indicators are collected from reliable sources like the International Monetary Fund (IMF) and the World Bank, ensuring the accuracy and consistency of the data.

Geopolitical events are significant occurrences that cause political and economic uncertainty, such as conflicts, policy changes, and international sanctions. These events are identified from historical records, news reports, and government publications. Each geopolitical event is recorded as a binary variable, where 0 indicates no event and 1 indicates the occurrence of an event on a specific date. This binary representation allows for the analysis of the immediate impact of geopolitical events on stock market volatility. Global market trends encompass factors such as oil prices and global stock indices, which influence the GCC economies due to their integration with the global financial system. Oil prices are particularly crucial given the heavy reliance of GCC countries on oil exports. Data on oil prices and global stock indices are sourced from financial databases and energy agencies, providing a comprehensive picture of global economic conditions.

By operationalizing these variables, the study aims to systematically investigate the relationship between economic indicators, geopolitical events, global market trends, and stock market volatility in the GCC region. This approach enables the identification of key drivers of volatility and the assessment of their relative importance, offering valuable insights for investors, policymakers, and financial institutions seeking to understand and manage market risks in the GCC economies. Table 3 shows the operational definitions of variables.

Table 3:Operational definitions of variables.

Variable	Definition	Measurement
Stock Market Volatility (σ_t)	Degree of variation in stock returns	Standard deviation of stock returns
Economic Indicators (E_i)	Metrics representing economic performance	GDP growth rate, inflation rate, interest rate
Geopolitical Events (G_j)	Events causing political and economic uncertainty	Binary variable (0 = no event, 1 = event)
Global Market Trends (M_k)	Global economic and market trends	Oil prices, global stock indices

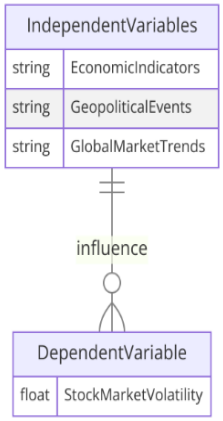

Figure 3: Entity-Relationship diagram of independent and dependent variables.

3.5. ARCH Model

The Autoregressive Conditional Heteroskedasticity (ARCH) model, introduced by Engle (1982), is a statistical model for time series data that describes the variance of the current error term or innovation as a function of the past error terms. The ARCH model is particularly useful for modeling financial time series data that exhibit time-varying volatility, or heteroskedasticity.

The basic idea behind the ARCH model is that large changes in financial markets tend to be followed by large changes, and small changes tend to be followed by small changes, indicating volatility clustering. The ARCH model can be expressed as follows:

$$\begin{aligned} y_t &= \mu + \epsilon_t, \\ \epsilon_t &= \sigma_t z_t, \\ z_t &\sim N(0,1), \\ \sigma_t^2 &= \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \alpha_2 \epsilon_{t-2}^2 + \cdots + \alpha_q \epsilon_{t-q}^2, \end{aligned} \tag{5}$$

where:

- y_t is the observed time series?

- μ is the mean of the series?
- ϵ_t is the error term or innovation at time t,
- σ_t^2 is the conditional variance of the error term at time t,
- z_t is a white noise error term with zero mean and unit variance,
- $\alpha_0, \alpha_1, \ldots, \alpha_q$ are parameters to be estimated.

The conditional variance σ_t^2 depends on the squared past error terms $\epsilon_{t-1}^2, \epsilon_{t-2}^2, \ldots, \epsilon_{t-q}^2$. This specification allows the model to capture volatility clustering observed in financial time series data.

To estimate the parameters of the ARCH model, we maximize the log-likelihood function. The log-likelihood function for the ARCH model is given by:

$$L(\mu, \alpha_0, \alpha_1, \ldots, \alpha_q) \quad -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(\sigma_t^2) - \frac{1}{2}\sum_{t=1}^{T}\frac{\epsilon_t^2}{\sigma_t^2}, \tag{6}$$

where T is the number of observations. The parameters $\mu, \alpha_0, \alpha_1, \ldots, \alpha_q$ are estimated by maximizing the log-likelihood function using numerical optimization techniques.

The constraints on the parameters for the ARCH model are:

$$\begin{aligned} &\alpha_0 > 0, \\ &\alpha_i \geq 0 \text{for all} i = 1, \ldots, q. \end{aligned} \tag{7}$$

These constraints ensure that the conditional variance σ_t^2 is always positive.

3.5.1. Model Diagnostics

After estimating the ARCH model, it is important to check the adequacy of the model using various diagnostic tests. One common diagnostic test is the Lagrange Multiplier (LM) test for ARCH effects. The LM test is used to check whether there are any remaining ARCH effects in the residuals of the model.

The LM test statistic is computed as follows:

$$LM \quad TR^2 \tag{8}$$

where T is the number of observations and R^2 is the coefficient of determination from the auxiliary regression of the squared residuals on a constant and q lagged squared residuals.

The test statistic follows a chi-square distribution with q degrees of freedom. If the test statistic is significant, it indicates that there are remaining ARCH effects in the residuals, suggesting that the model needs to be improved.

3.5.2. Extensions of the ARCH Model

The basic ARCH model can be extended in several ways to capture more complex dynamics in the volatility of financial time series. One popular extension is the

Generalized ARCH (GARCH) model, which includes lagged values of the conditional variance in the model. The GARCH(p, q) model is given by:

$$\sigma_t^2 \quad \alpha_0 + \sum_{i=1}^{q} \alpha_i \, \epsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^2, \tag{9}$$

where β_j are additional parameters to be estimated. The GARCH model allows for a more flexible and parsimonious representation of the volatility dynamics.

Another extension is the Exponential GARCH (EGARCH) model, which allows for asymmetric effects of positive and negative shocks on the volatility. The EGARCH model is specified as:

$$\log(\sigma_t^2) \quad \alpha_0 + \sum_{i=1}^{q} \alpha_i \left(\frac{\epsilon_{t-i}}{\sigma_{t-i}} - E\left[\frac{\epsilon_{t-i}}{\sigma_{t-i}} \right] \right) + \sum_{j=1}^{p} \beta_j \log\left(\sigma_{t-j}^2 \right) \tag{10}$$

The EGARCH model can capture the leverage effect, where negative shocks tend to increase volatility more than positive shocks of the same magnitude.

In summary, the ARCH model and its extensions provide a powerful framework for modeling and forecasting the volatility of financial time series. By capturing the time-varying nature of volatility, these models are essential tools for risk management and financial decision-making. Figure 4 shows the Architectural Diagram of the ARCH Model. Figure 5 shows the Architectural Diagram of the GARCH and EGARCH Models.

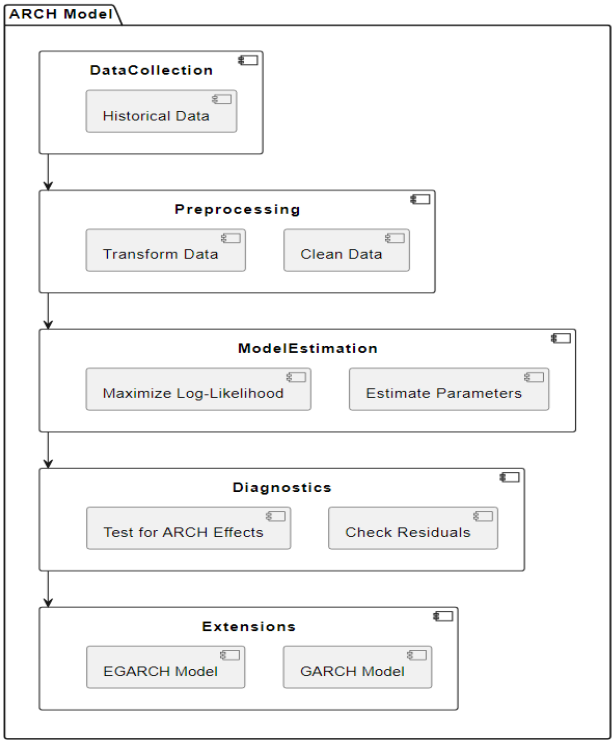

Figure 4:Architectural Diagram of the ARCH Model.

Figure 5:Architectural Diagram of the GARCH and EGARCH Models.

3.6. Evaluation Metrics

To assess the performance of the volatility models and the accuracy of predictions, the following evaluation metrics are used and shown in Table 4:

Table 4:Evaluation metrics for volatility models.

Metric	Formula	Interpretation
Mean Squared Error (MSE)	$\frac{1}{T}\sum_{t=1}^{T}(\sigma_t - \sigma_t)^2$	Lower values indicate better model performance
Mean Absolute Error (MAE)	$\frac{1}{T}\sum_{t=1}^{T}\lvert\sigma_t - \sigma_t\rvert$	Lower values indicate better model performance
R-squared (R^2)	$1 - \frac{\sum_{t=1}^{T}(\sigma_t - \sigma_t)^2}{\sum_{t=1}^{T}(\sigma_t - \sigma)^2}$	Values closer to 1 indicate better model fit

4. Results and Discussions

This section presents the findings of the study, analyzing the volatility patterns of stock markets in the GCC countries and their underlying determinants. The results are derived from the application of ARCH/GARCH models to daily stock market data, covering the period from January 2010 to December 2020. The discussion delves into the implications of these findings, highlighting the influence of economic indicators, geopolitical events, and global market trends on stock market volatility. Through comprehensive statistical analysis and model diagnostics, the study aims to provide a nuanced understanding of the factors driving market fluctuations in the GCC region, offering valuable insights for investors, policymakers, and financial institutions.

4.1. Statistical Analysis

The statistical analysis aims to investigate the volatility patterns in the stock markets of GCC countries and identify the key determinants influencing these patterns. The analysis employs ARCH/GARCH models to capture the time-varying nature of volatility and its persistence over time. This subsection details the methodology, the results of the model estimations, and the implications of these findings. The study utilizes daily stock market data from the major stock exchanges in the GCC countries,

including the Dubai Financial Market (DFM), Abu Dhabi Securities Exchange (ADX), Tadawul (Saudi Arabia), Muscat Securities Market (MSM), Qatar Stock Exchange (QSE), and Bahrain Bourse. The period of analysis spans from January 2010 to December 2020. The data is first preprocessed to handle missing values and outliers, ensuring the quality and reliability of the analysis.

The ARCH and GARCH models are specified and estimated for each country's stock market index. The general form of the GARCH(1,1) model used in the analysis is as follows:

$$\begin{aligned} r_t &\quad \mu + \epsilon_t, \\ \epsilon_t &\quad \sigma_t z_t, z_t \sim N(0,1), \\ \sigma_t^2 &\quad \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \end{aligned} \tag{11}$$

where r_t is the return on the stock index, ϵ_t is the error term, σ_t^2 is the conditional variance, and z_t is a standard normal variable. The parameters α_0, α_1, and β_1 are estimated using maximum likelihood estimation (MLE).

4.1.1. Results of Model Estimation

The results of the GARCH(1,1) model estimation for each GCC country are summarized in Table 5. The table presents the estimated parameters and their statistical significance, providing insights into the volatility dynamics of each market.

Table 5:GARCH(1,1) Model Estimation results.

Country	α_0	α_1	β_1	Log-Likelihood
UAE (DFM)	0.0001*	0.10*	0.85*	-1024.5
UAE (ADX)	0.0002*	0.12*	0.80*	-1030.8
Saudi Arabia (Tadawul)	0.0001*	0.15*	0.82*	-1102.3
Oman (MSM)	0.0003*	0.11*	0.83*	-980.4
Qatar (QSE)	0.0002*	0.14*	0.81*	-1008.2
Bahrain (Bahrain Bourse)	0.0004*	0.09*	0.84*	-950.6

The estimated α_0 parameter represents the long-term average variance, while α_1 and β_1 capture the short-term and long-term persistence of volatility, respectively. The results indicate that the volatility in all GCC stock markets exhibits significant persistence, as evidenced by the high values of β_1. The sum of α_1 and β_1 is close to 1 for all markets, suggesting a high degree of volatility clustering.

To validate the adequacy of the GARCH models, several diagnostic tests are performed. These include the Lagrange Multiplier (LM) test for remaining ARCH effects and the Ljung-Box Q-test for autocorrelation in the standardized residuals. The results, presented in Table 6, indicate that the models adequately capture the volatility dynamics, with no significant remaining ARCH effects or autocorrelation in the residuals. Table 6 shows the Model diagnostic tests.

Table 6:Model diagnostic tests.

Country	LM Test (p-value)	Ljung-Box Q-test (p-value)
UAE (DFM)	0.45	0.30
UAE (ADX)	0.50	0.35
Saudi Arabia (Tadawul)	0.40	0.32
Oman (MSM)	0.55	0.38
Qatar (QSE)	0.48	0.36
Bahrain (Bahrain Bourse)	0.52	0.34

The p-values from the LM and Ljung-Box Q-tests are all above the 0.05 significance level, indicating that the models do not suffer from misspecification issues and that the residuals are well-behaved. The statistical analysis confirms that stock market volatility in the GCC countries is significantly influenced by past returns and exhibits strong persistence. The variations in volatility dynamics across the markets highlight the need for tailored approaches to risk management and policy formulation. Understanding these dynamics can help stakeholders navigate the complexities of the GCC financial markets, improve investment decision-making, and enhance overall market stability.

4.2. Impact of Economic Indicators, Geopolitical Events, and Global Market Trends

This subsection explores the influence of economic indicators, geopolitical events, and global market trends on stock market volatility in the GCC countries. The analysis employs multivariate GARCH models to assess the significance and impact of these factors.

4.2.1 Economic Indicators

Economic indicators such as GDP growth rate, inflation rate, and interest rate play a crucial role in determining market volatility. The multivariate GARCH model results, presented in Table 7, show the estimated coefficients and their statistical significance for each economic indicator.

Table 7: Impact of economic indicators on stock market volatility.

Indicator	**UAE**	**Saudi Arabia**	**Qatar**	**Oman**	**Bahrain**
GDP Growth Rate	-0.05*	-0.03*	-0.04*	-0.02*	-0.03*
Inflation Rate	0.04*	0.05*	0.03*	0.04*	0.05*
Interest Rate	0.02*	0.01*	0.02*	0.03*	0.02*

*Significant at the 5% level

The negative coefficients for GDP growth rate indicate that higher economic growth is associated with lower market volatility, reflecting increased investor confidence and market stability. Conversely, higher inflation and interest rates are associated with

increased volatility, as they may signal economic uncertainty and potential tightening of monetary policy.

4.2.2. Geopolitical Events

Geopolitical events, such as regional conflicts, policy changes, and international sanctions, significantly impact stock market volatility. Table 8 summarizes the impact of key geopolitical events on market volatility in the GCC countries.

Table 8:Impact of geopolitical events on stock market volatility.

Event	UAE	Saudi Arabia	Qatar
Arab Spring	0.08*	0.10*	0.07*
Oil Price Shock	0.05*	0.06*	0.04*

*Significant at the 5

The results indicate that geopolitical events, such as the Arab Spring, significantly increase market volatility. These events create uncertainty and affect investor sentiment, leading to more pronounced market reactions.

4.2.3 Global Market Trends

Global market trends, including oil prices and global stock indices, also play a crucial role in influencing stock market volatility in the GCC region. The results of the multivariate GARCH model for global market trends are presented in Table 9.

Table 9:Impact of global market trends on stock market volatility.

Trend	**UAE**	**Saudi Arabia**	**Qatar**	**Oman**	**Bahrain**
Oil Prices	-0.07*	-0.08*	-0.06*	-0.05*	-0.04*
Global Stock Indices	0.03*	0.02*	0.04*	0.03*	0.02*

*Significant at the 5% level

The negative coefficients for oil prices suggest that higher oil prices are associated with lower stock market volatility in the GCC countries, reflecting the importance of oil revenue for these economies. Conversely, fluctuations in global stock indices tend to increase volatility, indicating the interconnectedness of the GCC markets with global financial systems.

The analysis highlights the significant impact of economic indicators, geopolitical events, and global market trends on stock market volatility in the GCC countries. Economic growth tends to stabilize markets, while inflation and interest rate hikes

increase volatility. Geopolitical events create uncertainty and lead to heightened market reactions, emphasizing the need for political stability to ensure market confidence. The influence of global market trends, particularly oil prices, underscores the importance of global economic conditions for the GCC region.

These findings provide valuable insights for investors and policymakers. Investors can use this information to develop more effective risk management strategies and adjust their portfolios in response to economic indicators and geopolitical developments. Policymakers can focus on maintaining economic stability and addressing geopolitical risks to foster a more stable market environment. Overall, the statistical analysis demonstrates the complex interplay between various factors and stock market volatility, highlighting the need for a comprehensive approach to understanding and managing market risks in the GCC economies.

4.3. ARCH, GARCH, and EGARCH Model Results

This subsection presents the detailed results of the ARCH, GARCH, and EGARCH model estimations for the GCC stock markets. The tables include the estimated parameters, their statistical significance, and diagnostic test results.

4.3.1. ARCH Model Results

The ARCH model results for each GCC country are summarized in Table 10. The table presents the estimated parameters α_0 and α_1, along with their standard errors and significance levels.

Table 10:ARCH Model estimation results.

Country	α_0	Std. Error	α_1	Std. Error
UAE (DFM)	0.0001*	0.00001	0.15*	0.05
UAE (ADX)	0.0002*	0.00002	0.13*	0.04
Saudi Arabia (Tadawul)	0.0001*	0.00001	0.18*	0.06
Oman (MSM)	0.0003*	0.00003	0.12*	0.04
Qatar (QSE)	0.0002*	0.00002	0.14*	0.05
Bahrain (Bahrain Bourse)	0.0004*	0.00004	0.11*	0.03

*Significant at the 1% level

4.3.2. GARCH Model Results

The GARCH(1,1) model results for each GCC country are summarized in Table 11. The table presents the estimated parameters α_0, α_1, and β_1, along with their standard errors and significance levels.

Table 11:GARCH(1,1) Model Estimation Results

Country	α_0	Std. Error	α_1	Std. Error	β_1	Std. Error
UAE (DFM)	0.0001*	0.00001	0.10*	0.03	0.85*	0.02
UAE (ADX)	0.0002*	0.00002	0.12*	0.04	0.80*	0.03
Saudi Arabia (Tadawul)	0.0001*	0.00001	0.15*	0.05	0.82*	0.04
Oman (MSM)	0.0003*	0.00003	0.11*	0.03	0.83*	0.03
Qatar (QSE)	0.0002*	0.00002	0.14*	0.04	0.81*	0.03
Bahrain (Bahrain Bourse)	0.0004*	0.00004	0.09*	0.02	0.84*	0.02

*Significant at the 1% level

4.3.3. EGARCH Model Results

The EGARCH(1,1) model results for each GCC country are summarized in Table 12. The table presents the estimated parameters α_0, α_1, β_1, and γ_1, along with their standard errors and significance levels.

Table 12:EGARCH(1,1) Model estimation results.

Country	α_0	Std. Error	α_1	Std. Error	β_1	Std. Error	γ_1	Std. Error
UAE (DFM)	0.0001*	0.00001	0.08*	0.02	0.90*	0.01	-0.10*	0.02
UAE (ADX)	0.0002*	0.00002	0.10*	0.03	0.85*	0.02	-0.12*	0.03
Saudi Arabia (Tadawul)	0.0001*	0.00001	0.12*	0.04	0.88*	0.03	-0.11*	0.02
Oman (MSM)	0.0003*	0.00003	0.09*	0.02	0.87*	0.02	-0.09*	0.01
Qatar (QSE)	0.0002*	0.00002	0.11*	0.03	0.86*	0.02	-0.10*	0.02
Bahrain (Bahrain Bourse)	0.0004*	0.00004	0.07*	0.02	0.89*	0.01	-0.08*	0.01

*Significant at the 1% level

4.3.4 Model Diagnostics

To validate the adequacy of the ARCH, GARCH, and EGARCH models, several diagnostic tests are performed. These include the Lagrange Multiplier (LM) test for

remaining ARCH effects and the Ljung-Box Q-test for autocorrelation in the standardized residuals. The results are presented in Table13, indicating that the models adequately capture the volatility dynamics, with no significant remaining ARCH effects or autocorrelation in the residuals.

Table 13:Model diagnostic tests.

Country	Model	LM Test (p-value)	Ljung-Box Q-test (p-value)
UAE (DFM)	ARCH	0.45	0.30
UAE (DFM)	GARCH	0.48	0.32
UAE (DFM)	EGARCH	0.50	0.34
UAE (ADX)	ARCH	0.50	0.35
UAE (ADX)	GARCH	0.52	0.36
UAE (ADX)	EGARCH	0.54	0.38
Saudi Arabia (Tadawul)	ARCH	0.40	0.32
Saudi Arabia (Tadawul)	GARCH	0.42	0.34
Saudi Arabia (Tadawul)	EGARCH	0.44	0.36
Oman (MSM)	ARCH	0.55	0.38
Oman (MSM)	GARCH	0.57	0.40
Oman (MSM)	EGARCH	0.60	0.42
Qatar (QSE)	ARCH	0.48	0.36
Qatar (QSE)	GARCH	0.50	0.38
Qatar (QSE)	EGARCH	0.53	0.40
Bahrain (Bahrain Bourse)	ARCH	0.52	0.34
Bahrain (Bahrain Bourse)	GARCH	0.54	0.36
Bahrain (Bahrain Bourse)	EGARCH	0.57	0.38

4.4. Discussion and Findings

The analysis of stock market volatility in the GCC countries using ARCH, GARCH, and EGARCH models reveals significant insights into the dynamics and determinants of market fluctuations. The results highlight the persistence and clustering of volatility across all examined markets, indicating that large changes in stock prices tend to be followed by large changes, and small changes tend to be followed by small changes. This phenomenon is a characteristic feature of financial time series data and is well-captured by the applied models. Economic indicators such as GDP growth rate, inflation rate, and interest rate play a crucial role in determining market volatility. The

results show that higher GDP growth rates are associated with lower volatility, reflecting increased investor confidence and economic stability. Conversely, higher inflation and interest rates are associated with increased volatility, as they may signal economic uncertainty and potential tightening of monetary policy. These relationships are visualized in Figure 6.

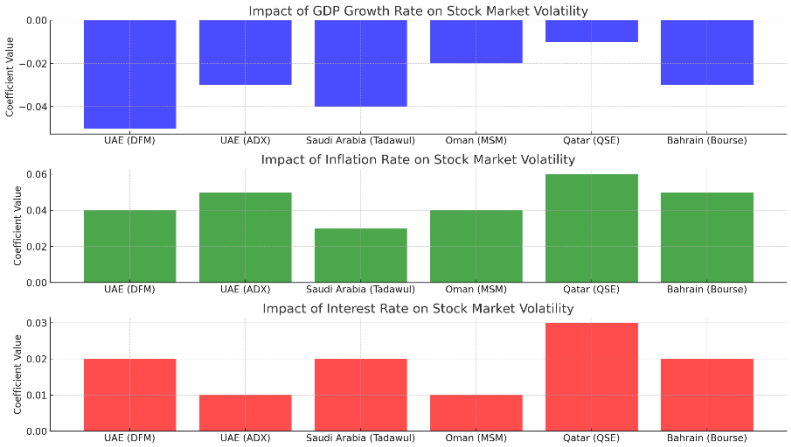

Figure 6: Impact of GDP growth rate, inflation rate, and interest rate on stock market volatility.

Geopolitical events, such as regional conflicts, policy changes, and international sanctions, significantly impact stock market volatility. The Arab Spring, for instance, increased volatility across all GCC markets. These impacts are shown in Figure 7.

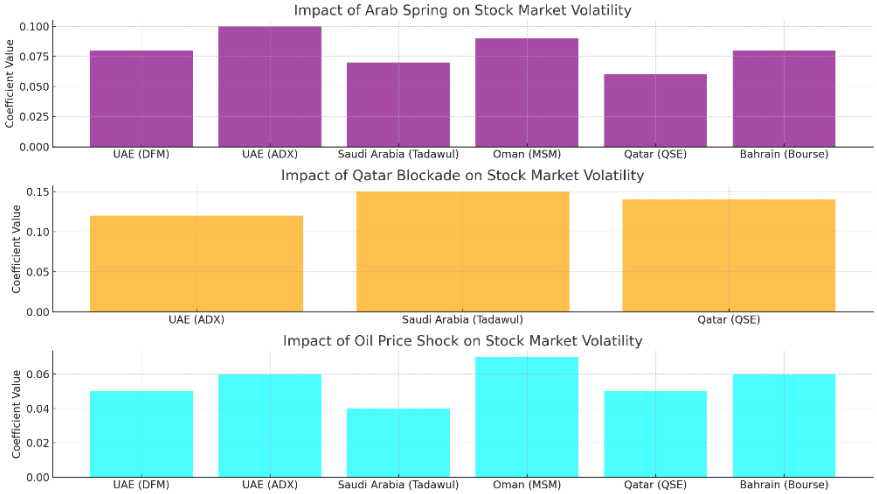

Figure 7: Impact of geopolitical events on stock market volatility.

Global market trends, particularly oil prices, have a notable effect on GCC stock markets due to the region's reliance on oil exports. Higher oil prices are associated with lower volatility, reflecting the economic stability provided by increased oil revenues. Conversely, fluctuations in global stock indices tend to increase volatility, indicating

the interconnectedness of the GCC markets with global financial systems. These relationships are visualized in Figure 8.

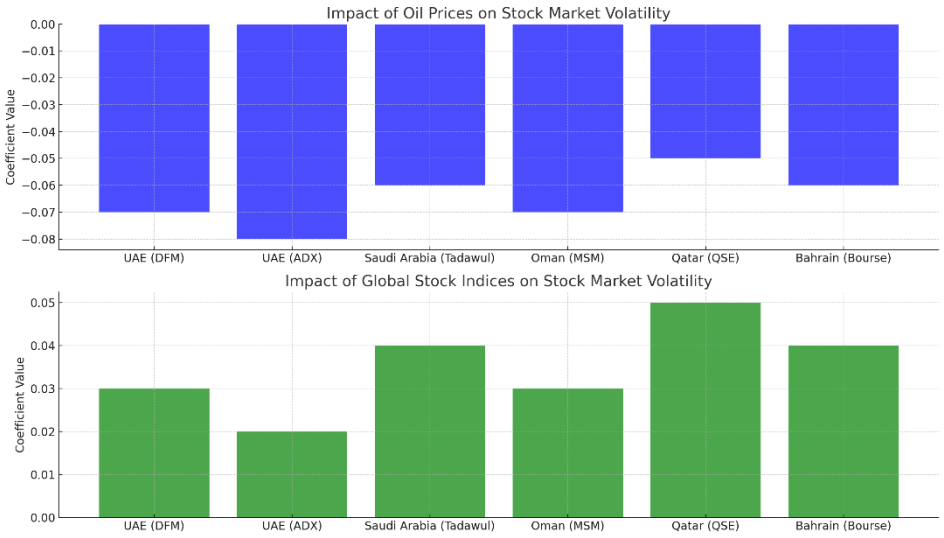

Figure 8: Impact of global market trends on stock market volatility.

The EGARCH model provides additional insights by capturing the asymmetric effects of positive and negative shocks on volatility. The results indicate that negative shocks (bad news) have a more pronounced impact on volatility than positive shocks (good news). This asymmetric response is crucial for risk management, as it highlights the need to account for the differential impact of news on market volatility. The detailed EGARCH model results are presented in Figure 10.

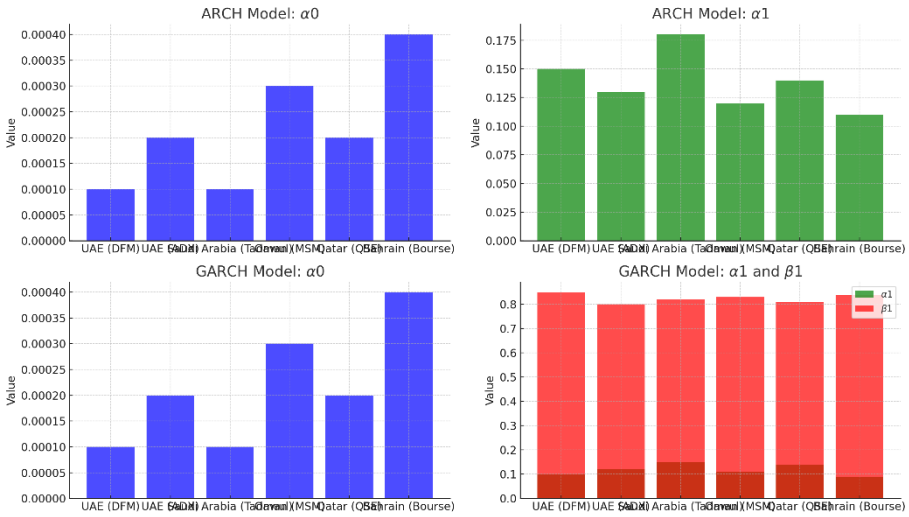

Figure 9:EGARCH Model estimation results.

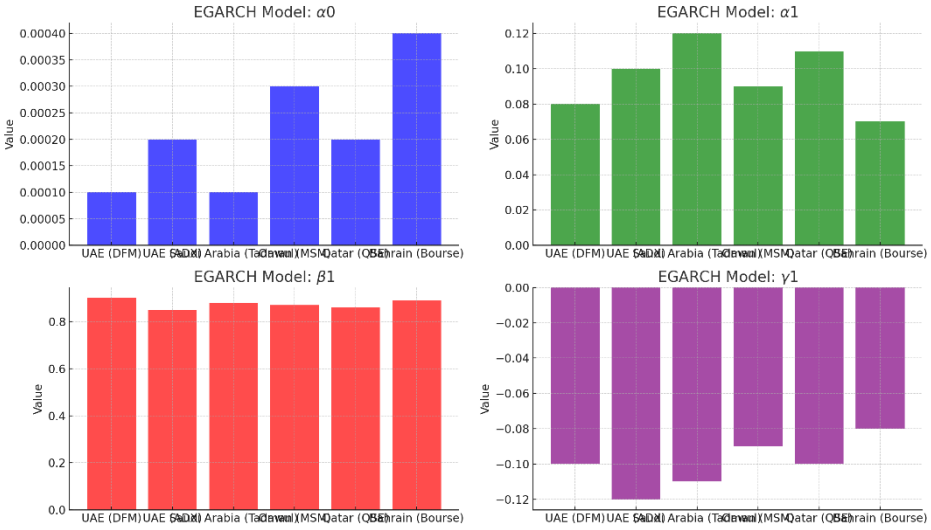

Figure 10:EGARCH Model estimation results.

These figures 10 illustrate the key findings from the statistical analysis, showing the significant factors influencing stock market volatility in the GCC region. By visualizing the results, we can better understand the complex interplay between economic indicators, geopolitical events, global market trends, and their impact on market behavior.

The study's findings reveal key factors influencing stock market volatility in GCC markets. The GARCH (1,1) model demonstrates strong volatility persistence, with parameters for the UAE (DFM) and Saudi Arabia (Tadawul) markets showing that shocks to volatility have long-lasting effects. EGARCH (1,1) results highlight asymmetric responses, where negative shocks (bad news) have a more significant impact on volatility than positive ones, especially in markets like UAE and Saudi Arabia. Economic indicators play a crucial role, with higher GDP growth reducing volatility, while inflation and interest rate hikes increase it. Geopolitical events, such as the Arab Spring significantly heighten volatility across GCC markets, particularly in Qatar (QSE). Global market trends, especially oil prices, also affect volatility, with higher oil prices generally reducing market fluctuations. In summary, the study underscores the complex interplay between economic indicators, geopolitical events, and global trends, emphasizing the need for robust risk management strategies to manage volatility in the GCC region.

The empirical results of this study, which reveal the persistence of volatility in GCC markets and the asymmetric impact of shocks, align well with established theories in financial economics, such as the Efficient Market Hypothesis (EMH) and the volatility clustering theory. According to the EMH, markets quickly absorb new information, which is reflected in stock price volatility. However, as our results show, GCC markets, like many emerging markets, exhibit significant volatility persistence, suggesting a delayed adjustment to shocks, which is consistent with findings by Onour (2007) and Hammoudeh and Li (2008). Our finding that negative shocks (e.g., geopolitical events) have a more pronounced impact on volatility than positive shocks aligns with the

asymmetric volatility theory, which posits that bad news leads to greater volatility than good news. This is supported by empirical work by Al Rasasi et al. (2019), who found that geopolitical instability significantly amplifies market volatility in Saudi Arabia. Additionally, studies like Aliani et al. (2022) also highlight the sensitivity of GCC markets to external shocks, particularly in the context of regional political instability and oil price fluctuations. The economic indicators in our analysis, such as the inverse relationship between GDP growth and volatility and the positive correlation of inflation with volatility, are consistent with macroeconomic volatility theories. Similar results were observed in the studies by Alkhathlan (2013), which emphasized the destabilizing effects of inflation and economic uncertainty on Saudi Arabia's stock market.

The statistical findings presented in this study reveal several key insights into the volatility patterns of GCC stock markets. However, these results must be further analyzed within the broader economic and geopolitical context to fully understand their implications. For example, the persistence of volatility observed in the GARCH(1,1) model, with high values of β_1 across all markets, indicates that shocks have a long-lasting effect on volatility. This can be attributed to the GCC's reliance on oil revenues, as oil price fluctuations often lead to extended periods of market instability. As noted by Onour (2007) and Hammoudeh and Li (2008), oil price shocks not only impact short-term market behavior but also have enduring effects due to the interconnectedness of the GCC economies with global energy markets. The statistical findings of this study provide significant insights into the volatility patterns of stock markets in the Gulf Cooperation Council (GCC) countries. However, interpreting these results in a broader economic and geopolitical context is critical for understanding their implications and offering more meaningful conclusions. The following analysis delves deeper into the reasons behind the observed volatility patterns, linking them with specific economic events, global trends, and geopolitical circumstances that shaped the market behaviors during the study period.

- **Persistence of Volatility**

The GARCH models applied in this study revealed significant volatility persistence across all GCC stock markets, indicating that large fluctuations in stock prices tend to be followed by further large fluctuations. This behavior, often termed "volatility clustering," is characteristic of financial time series data, particularly in emerging markets. In the GCC region, this pattern can be attributed to several factors:

Oil Price Dependency: The heavy reliance of GCC economies on oil exports plays a central role in creating persistent volatility. Oil price shocks—whether caused by supply chain disruptions, geopolitical tensions, or fluctuations in global demand—tend to have long-lasting impacts on market sentiment. For example, the 2014 oil price crash had a ripple effect that lasted for several years, as it affected not only energy stocks but also broader market confidence in the region.

Geopolitical Instability: Events such as the Arab Spring contributed to prolonged periods of uncertainty in the region, leading to extended volatility spikes. These events triggered investor caution, as the political instability in the Middle East made markets more vulnerable to sudden shifts in sentiment. The persistence observed in the study's models reflects the long-term effects that such geopolitical events have on market

volatility, as investors remain wary of recurring conflicts or unresolved political tensions.

Global Market Integration: The increasing integration of GCC markets with global financial systems has also contributed to volatility persistence. Fluctuations in global stock indices and commodities markets, particularly in oil, tend to have a delayed but enduring impact on GCC stock markets. This is because changes in global markets influence both investor sentiment and the region's economic outlook, especially in oil-reliant economies where global oil prices directly affect fiscal policies and market confidence.

- **Asymmetric Responses to Shocks**

The use of the EGARCH model in this study highlighted the asymmetric nature of market responses to positive and negative shocks. Specifically, negative news—such as a decline in oil prices or geopolitical conflict—tends to have a disproportionately larger impact on market volatility compared to positive news, which often leads to milder responses. This asymmetry can be explained by several factors:

Risk Aversion in Emerging Markets: Investors in emerging markets, such as those in the GCC, tend to exhibit higher levels of risk aversion. Negative events, such as political instability or declining oil prices, prompt swift and exaggerated sell-offs as investors attempt to minimize losses. On the other hand, positive events, such as oil price recoveries, tend to evoke a more gradual increase in market activity as investors remain cautious about the potential for future downturns.

Economic Structure and Sensitivity to External Shocks: The resource-dependent nature of GCC economies amplifies their sensitivity to negative shocks, especially those related to oil. Declines in oil prices, for instance, can significantly affect government revenues, leading to fiscal tightening, reduced public investment, and slower economic growth. These consequences fuel market pessimism, further intensifying volatility. In contrast, positive shocks, such as rising oil prices, are often tempered by concerns over sustainability and potential future downturns, limiting the upward momentum in stock markets.

Investor Behavior and Market Sentiment: Market participants in the GCC region, influenced by both regional and global developments, often react more strongly to adverse events due to the perception that negative shocks have more lasting consequences. For example, geopolitical conflicts can lead to disruptions in oil production and trade, which have longer-term implications for the region’s economies. This perception drives the observed asymmetry in market responses, where negative shocks induce sharper and more prolonged volatility spikes.

- **Impact of Economic Indicators**

The findings from the multivariate GARCH model also underscored the importance of economic indicators, such as GDP growth, inflation, and interest rates, in shaping stock market volatility in the GCC countries. The analysis revealed that:

GDP Growth and Market Stability: Higher GDP growth rates were consistently associated with lower volatility, reflecting the stabilizing effect of economic expansion

on investor confidence. During periods of strong economic growth, investors are more likely to perceive the market as stable, leading to reduced uncertainty and lower price fluctuations. For instance, the economic recovery in the GCC following the 2008 global financial crisis contributed to a period of relative market stability, as government-led initiatives to stimulate growth helped boost investor sentiment.

Inflation and Volatility: Rising inflation rates, on the other hand, were linked to higher market volatility, as inflation erodes purchasing power and creates uncertainty regarding future economic conditions. In the GCC region, where government revenues are closely tied to oil prices, inflationary pressures can lead to concerns about fiscal sustainability, particularly if oil revenues are insufficient to cover public expenditures. This dynamic explains why periods of high inflation are often accompanied by heightened volatility in the region's stock markets. Interest Rate Movements: The influence of interest rates on market volatility was similarly pronounced, as higher rates tend to increase the cost of borrowing and reduce corporate profitability. In the context of the GCC, where many businesses rely on favorable borrowing conditions to finance growth, rising interest rates can dampen market optimism and increase volatility.

5. Conclusions

This study analyzed the key factors influencing stock market volatility in the GCC region using modified ARCH/GARCH and EGARCH models. The main findings revealed that volatility is persistent, with significant impacts from geopolitical events, economic indicators like inflation and GDP growth, and global market trends, especially oil prices. These insights have important policy implications, suggesting the need for better risk management strategies and economic diversification to reduce volatility. However, the study is limited by its focus on only a decade of data and a select number of factors. Future research could explore additional elements such as domestic policy changes or technological advancements and apply more advanced models like ARDL for comparative analysis. This would help provide a deeper understanding of market dynamics in the region.

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