Investigating Stock Market Volatility in Saudi Arabia Using the GARCH and EGARCH Models

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Abstract

Stock market acts as a key component of an economy by promoting capital creation, improves liquidity by bringing investments to the nation. It promotes economic growth, industrial development and employment. Saudi stock market known as Tadawul plays a significant role in shaping nations development and long term plans while it is also crucial for financial dynamics natively and worldwide. This paper aims to investigate the stock market volatility by applying GARCH and EGARCH models using Tadawul All Share daily price index data taken from 3 July2010 to 19 August2024.The ARCH parameter is significant in descriptive statistics which indicates the presence of heteroskedasticity in squared residuals demonstrating the need of applying GARCH model. Moreover, ARCH and GARCH terms are statistically significant in both models of study. While positive leverage value presence also suggests that, due to existence of asymmetric behavior the negative shocks in markets entail a higher impact than positive shocks in upcoming time period. Through findings of this study the major repercussions in stock market after the 2008 economic crisis can be seen. This study contributes towards the existing literature about stock market volatility research and it can also help investors to better gauge about the unpredictability of stock market shares due to existence of market instability. It also suggests that it is better to invest in diversified markets to lower the risk factor when markets are facing world crisis.

Keywords: Stock market volatility, GARCH, EGARCH, Saudi stock exchange.

Introduction

The world economic recession 2008 has affected the economic stability of every nation. Due to economists increasing interest towards the stock markets and its volatility in developing nations like Saudi Arabia the stock market volatility research is an important paradigm for economic development. The Saudi stock market and oil prices continue to have a major link, amid Saudi Arabia's Vision 2030 to be less dependent on oil.

For this reason, knowledge of connection between oil and stock markets is crucial for decision-making and economic stability, particularly in the Saudi setting (Abdou et al., 2024). Furthermore, the COVID-19 pandemic caused market disturbances for crude oil and stock exchanges, which further complicated the dynamics of the world's financial system. The aim of this research is to investigate instability in stock prices with a special emphasis on the Saudi stock market and its connections to global stock markets and oil prices.

Stock markets have always been considered as an essential part of any economy. These markets are helpful in acquiring and selling securities i.e. stocks of the companies. They provide a platform for businesses to raise money through initial public offerings and help in promoting development and prosperity in the economy (Bala, 2013).

Financial risk is directly proportional to the tenure market volatility and noted as an important tool to improve stock movement predictions in both economic and statistical terms (Jiang, Liu, & Lu, 2023). The financial risk has its own unexpected elements also there are number of factors such as investor emotion and market dynamics that cause unexpected behaviors in the stock market and affect its efficiency (Dempsey, 2017). Similarly, derivatives are considered a major component of risk management for businesses and financial organizations. The stock market is divided into main and secondary markets (Kumar, 2014). Despite of having potential of huge returns, still there are many investors who prefer other platforms of investment instead of stock exchanges. The only reason behind this is the inherent instability and risks involved in the stock trading.

As explained by Bhawmik (2013), this uncertain behavior and the risk is caused by the financial risks, political turmoil and economic chaos. Stock Market volatility has also shown relationship with market emotions. Due to correlated errors in investor behavior even small mental costs can leads towards significant sentiment while increasing ambiguity and financial risk (Hassan&Merterns, 2011). Das et al. (2022) found the impact of public sentiment on forecasting the stock market by using sentiment analysis and achieved the accuracy up to 98.32%. Stock price volatility has a positive relationship with GDP and industrial productivity and also with commodities financialzation which has also a significant impact on broader economy during COVID-19 (Li et al., 2022).Market volatility has been an important topic in the field of financial research. It involves a very dynamic and multidimensional research approach. The paper is going to study the market volatility of the Saudi Stock exchange using GARCH family. The extensive literature has been presented secondly, following the theoretical framework and methodology thirdly. The conclusion and outcomes of study are presented at last.

Literature Review

In the financial markets volatility is important for hedging techniques, portfolio risk management and derivative pricing. As a result, precise volatility prediction is essential. The accuracy of stock price index volatility forecasting has shown considerable promise when Long Short-Term Memory (LSTM) networks are integrated with numerous GARCH-type models. For example, the MULTI-GARCH-LSTM model efficiently combines the GARCH model's ability to simulate volatility dynamics with the strengths of LSTM's ability to capture complicated nonlinear interactions, resulting in improved predictive performance when compared to individual models (Peng, Wang, & Tang, 2024). Further for increasing forecasting accuracy is done by combining several volatility indicators are advanced GARCH-type models that use combined weighted volatility measures (Kho et al., 2024). Additionally, research shows that LSTM networks perform better than conventional time series models like GARCH and ARIMA when managing the complexities of financial data, indicating that hybrid techniques can take progress from the advantages of both econometric and deep learning models (Dinda, 2024; Mohsin et al., 2021; Naseem et al., 2018).

According to the research findings, the Saudi stock market is growing mostly due to its economic development, income level, control over corruption, and market depth (Alalmai,2024). The strength of retail trading, attention to sharp price increases, firm profitability forecasting returns, and shifting investor emphasis affecting stock performance are some of the factors propelling the expansion of the

Saudi stock market (Alshammari&Goto, 2022).

Alhussayen (2022) investigates the factors influencing foreign institutional investments in the Saudi stock market and their effects on market stability by taking quarterly data from 2015 to 2019. His results exhibit foreign institutions are demonstrating herding and momentum behavior.

Shaddayand Alsaggaf (2020) argues that main forces behind the expansion of the Saudi stock market, particularly during initial public offerings (IPOs), are not business features but rather behavioral finance elements including optimism, overconfidence, loyalty, and herd behavior.

Shah et al. (2023) in his research findings examine the connections between Pakistan's macroeconomic indices, SMV and FPI (Foreign Portfolio Investment) and studies how fundamental breakdowns affect both internal and external disruptions.

According to Alqahtani et al. (2021) the Saudi Arabian equity market is influenced by both business size and international variables and to effectively navigate market expansion, risk management tactics may be strengthened by using quantile analysis and frequency domain causation.

When traders project a democratic victory it creates an influence on the stock market and becomes less volatile. To assess the accuracy of statistical models extensive forecasting experiments are performed. For volatility analysis, GARCH, EGARCH, FIEGARCH, and Markov-switching models are applied. Since forecasts produced by GARCH and EGARCH models are more precise than those using Markov-switching models (Leblang& Mukherjee, 2004; Naseem et al., 2019).

Bhowmik (2013) utilizes significant economic literature to examine a number of aspects of stock market volatility, such as measurement and the nature of volatility's influence. He also focuses on the political aspects of instability and make an effort to link economic growth and stock market volatility over the long term by investigating a few econometric models. It came to the conclusion that political conflict and depression increases stock market volatility, which in turn reduce national growth rates and has significant negative spillover effects on growth rates from volatility in other nations. He also explained econometric models which establish an asymmetric relationship between volatility and trade volume as volatility reduce trade volume while increase in current and capital account deficit are used to explain the relationship between volatility and international trade.

Theoretical Framework

Li (2022) build a theoretical foundation by conducting an experimental research on indexes and complex network models. The outcomes have shown that volatility data of financial market based on complex networks and fuzzy theory is more accurate. The asymmetric volatility phenomenon, in which market responses to profits and losses diverge dramatically, is the basis of the most well recognized proposition explaining stock market volatility. This knowledge has significant implications for portfolio management, especially with regard to asset allocation and risk assessment techniques. According to the theory, investors engage in mental framing, which causes them to rebalance their portfolios toward safer assets following wins and riskier ones following losses. An inverse relationship is established between unusual returns and later fluctuations as a result of this behavior (Ormos&Timotity, 2024). Scientific study demonstrates that volatility is not constant and that it fluctuates depending on the state of the market, especially under pressure. This can have a big influence on portfolio performance (Doan et al., 2018; Majeed et al., 2020).

Data and Methodology

Data Description

The study is based on deductive approach and secondary data has been used. Mono-method research approach is used because data is secondary. The time horizon is longitudinal. Tadawul all share data is obtained from investing.com website and it is publically available. The data is taken from 3 July2010 to 19 August2024 to evaluate the forecast of stock volatility. This time horizon is taken because before 2010 there was economic recession in the world in 2008 and to evaluate the counter-effects of this session the data has been selected.

Methodology

This study tends to use GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model to evaluate the volatility as it is used various researchers (Engle 2001; Ng and McAleer 2004; Patev and Kanaryan 2003). The returns of market price are taken as a dependent variable.

Mean equation is significantly important when applying GARCH model.

The equation is given as:

$$\textit{Mean Equation with constant,} \qquad r_t = \mu + \mathcal{E}_t$$

Volatility Modeling

A volatility model is employed to predict the absolute size of returns (Engle&Patton, 2001).Symmetrical and Asymmetrical models are the two main types of GARCH type models. According to Omari and Mwita et al. (2017) asymmetrical models measure the different effects of future volatility with same magnitude including positive and negative shocks while symmetrical models rely on magnitude only.

Symmetrical Model

GARCH (1, 1) Model

This model is considered among modern models in forecasting as this is different from ARIMA model which require the random term variance in time series to be constant. Moreover in most of economic and financial variables data such as stock prices and exchange rates this assumption does not fit. Therefore this model can give better description. GARCH models are widely utilized in many areas of econometrics, particularly in financial time series research.(Saeed, 2024).

It is denoted by (p, q) as:

$$r_t = \mu + y_t, \qquad y_t = \sigma_t + \mathcal{E}_t$$
$$\sigma_t^2 = \omega + \sum_{i=1}^{p} a_i\, y_{t-i}^2 + \sum_{j=1}^{q} \beta_j\, \sigma_{t-j}^2$$

Where logarithmic return of the financial time series with respect to time is denoted byr_t while μ denotes return's mean value and mean equation error term is shown by y_t and $\mathcal{E}_t$shows zero mean which is supposed to have normal distribution $\omega > 0$, $a_i \geq 0$, $\beta_i \geq 0$ where σ_t is dependent standard deviation.

$$\sigma_t^2 = \omega + a_i\, y_{t-i}^2 + \beta_j\, \sigma_{t-j}^2$$

$$\sum_{i=1}^{p} a_i + \sum_{j=1}^{q} \beta_j < 1$$

According to limitations $\omega > 0$ and $a_i \geq 0$, $\beta_i \geq 0$ a positive variance is confirmed. A new GARCH extension model as $a + \beta < 1$ this addresses the GARCH (1, 1) model's flaws and captures a number of financial time series characteristics to demonstrate the persistence of data.

Asymmetrical Model

Exponential GARCH (1, 1) EGARCH Model

Nonlinear GARCH models, like EGARCH, are used to determine the implications of asymmetric leverage and long and short-memory volatility.
Nelson (1991) developed the exponential GARCH model (EGARCH) which is based on the GARCH model and made improvements such as
Mean equation = $r_i = \mu + \mathcal{E}_t$

The dependent variable is logarithm of conditional variance and this model is used due to presence of conditional variance.

This model is represented as:

$$ln(\sigma_t^2) = \omega + \sum_{i=1}^{p} a_i \left|\frac{y_{t-1}}{\sigma_{t-i}}\right| + \gamma_i \frac{y_{t-1}}{\sigma_{t-i}} + \sum_{j=1}^{q} \beta_j ln\sigma_{t-j}^2$$

In this equation asymmetrical response parameter or leverage effect is represented by **γ** which can be with a positive or negative sign to show future uncertainty.

$$ln(\sigma_t^2) = \omega + a_1 \left|\frac{y_{t-1}}{\sigma_{t-1}}\right| + \gamma_1 \frac{y_{t-1}}{\sigma_{t-1}} + \beta_1 ln\sigma_{t-1}^2$$

When $\frac{y_{t-1}}{\sigma_{t-1}} > 0$ the equation is

$$ln(\sigma_t^2) = \omega + (a_1 + \gamma_1) \frac{y_{t-1}}{\sigma_{t-1}} + \beta_1 ln\sigma_{t-1}^2$$

When $\frac{y_{t-1}}{\sigma_{t-1}} < 0$ the equation is

$$ln(\sigma_t^2) = \omega + (a_1 + \gamma_1) \frac{y_{t-1}}{\sigma_{t-1}} + \beta_1 ln\sigma_{t-1}^2$$

Empirical Findings

The table#1 shows descriptive statistics for the daily stock prices. The daily average return (9.027269) with a positive standard deviation is given. While the skewness is also positive which means that most values are gathered around the left tail of the distribution while the right tail of the distribution is longer. ARCH test has statistically confirmed the ARCH affect presence in the data of returns which indicates GARCH techniques can be performed (Salamat et al., 2020; Shaw, 2018).

Table : 1 Descriptive Statistics

Stats.	Stock Prices (TASI)
Mean	9.027269
Median	8.98675
Maximum	9.533897
Minimum	8.579843
Std. Dev.	0.22369
Skewness	0.375405
Kurtosis	1.973225
ARCH	0.944577
Probability	0.00000
Observations	3539

Figure 1. RTASI

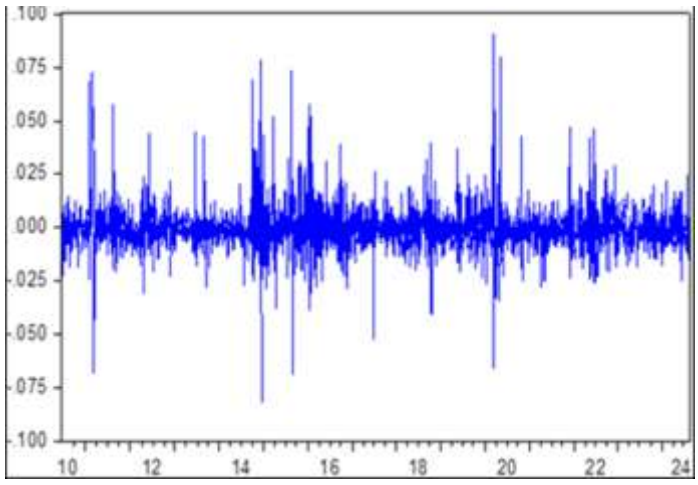
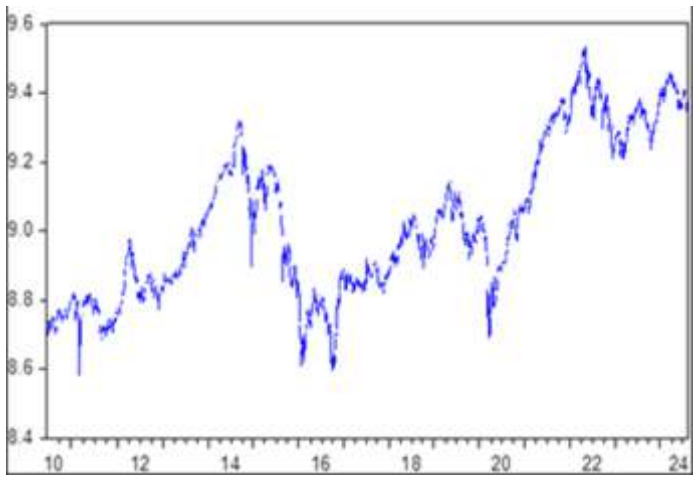


Figure 2. ln(TASI)



The graphical representation of returns of tadawul share prices and log of prices are given in figure 1 and 2 respectively. The variations are shown in both figures.

TABLE : 2 Normal Distribution

	Coefficients	Std. Error	z-Statistic	Prob.
Mean μ (Constant)	-0.000694	0.000141	-4.925396	0.00000
Varianceω (Constant)	4.79E-06	3.31E-07	14.47556	0.00000
a (ARCH term)	0.160244	0.008798	18.21309	0.00000
β (GARCH term)	0.805542	0.009075	88.76352	0.00000
α + β	0.965786	----------	----------	---------
LL	11687.78	----------	----------	---------
AIC	-6.602872	---------	----------	----------
SIC	-6.595896	----------	----------	----------
ARCH	0.192032	----------	----------	----------
Probability	0.6613	----------	----------	----------
Jarque-Bera	12795.97	---------	----------	----------
Probability	0.00000	---------	----------	----------

The table#2 describes the results of GARCH model by showing that mean constant value as -0.000694 and variance constant value (4.79E-06) significant. ARCH term α and GARCH term β are significant at 1%level. The coefficient of ARCH term as α is used to measure the influence of past errors on existing unpredictability. A greater α suggests that volatility of current period is more influenced by previous shocks. Coefficient of GARCH term β calculates how historical volatility influences the existing instability. Greater volatility with the passage of time is indicated by a larger β value. The persistency of error term is shown by the value of α+ β which is less than 1% (Mohsin et al., 2020).The value of Jarque-Bera is 12795.97 with probability value of 0.00 that indicate residuals are significant. To assess the residuals or errors normality in regression model Jarque-Bera test is used. It tests the scattering of residuals which either follows a normal distribution or not (Thadewal&Buning, 2007). Akaike and Schwarz information criterion overcome the drawbacks associated with R-square and adjusted R-square. Both these information criteria impose a penalty for including unnecessary independent variables in a study. To determine the fitness of a model and comparing different models information criterion are better to use. These criteria can be used to drop unnecessary independent variables. While with the lower values of AIC as -6.602872 and SIC as -6.595896 are preferred because it shows that there are no unnecessary parameters in the study model. ARCH term given in the table is 0.192032 with a probability of 0.6613 that is non-significant showing the model is good fit.

TABLE : 3 Normal Distribution

	Coefficients	Std. Error	z-Statistic	Prob.
Mean μ (Constant)	-0.000437	0.000132	-3.309775	0.00000
Varianceω(Constant)	-0.69186	0.031305	-22.10094	0.00000
α (ARCH term)	0.22715	0.011688	19.43403	0.00000
β (GARCH term)	0.133474	0.006304	21.17235	0.00000
γ (Leverage effect)	0.944577	0.002802	337.157	0.00000
α + β	0.360624	----------	----------	----------
LL	11775.68	----------	----------	----------
AIC	-6.651983	----------	----------	----------
SIC	-6.643264	----------	----------	----------
ARCH	0.111393	----------	----------	----------
Probability	0.7386	----------	----------	----------
Jarque-Bera	9917.273	----------	----------	----------
Probability	0.000000	----------	----------	----------

The table#3 explained the findings of EGARCH model while the mean constant value is -0.000437 and variance constant is -0.69186 which is significant. The ARCH and GARCH term is statistically significant at 1% level.Leverage term *y* gauges how much volatility is affected differently by adverse shocks compared to favorable events. Likewise, the leverage coefficient is positively significant at 1 %level (Salamat et al., 2019; Bouri et al., 2017).The convergence of $\alpha + \beta$ is less than 1 which means that error terms are persistent (Abdullahet al., 2017).The selection criterion (high LL and low AIC, SIC) values indicates that EGARCH model with normal distribution is a good fit model. ARCH term given in the table is 0.111393 with a probability of 0.7386 which is not significant that shows the model is good fit. The value of Jarque-Bera is 9917.273 with a probability of 0.00 which shows residuals are significant. These results confirm the reliability and stability of the projected model.

Conclusion

This study advances our knowledge of stock market volatility in Saudi Arabia using GARCH Family. It overcomes the limits of earlier researches by taking a data span after the world economic recession in order to find subsequent effects. The application of GARCH (1, 1) model to determine unpredictability in return series (Table 2) and asymmetric EGARCH (1, 1) model to determine the asymmetric effect in the presence of the ARCH effect is shown in Table 3. While all coefficients were significant at 1% level. By assessing the instability of stock shares using Tadawul all share data applying GARCH and EGARCH models for analysis both models have been found significant. The value of leverage coefficient *y* is positive (for EGARCH) which suggests the existence of asymmetric behavior that suggests the poor news or adverse circumstances exert a bigger impact on the fluctuations of the next period than beneficial events of same magnitude. This study implies the connection of stock market and financial crisis while the economic crisis of 2008 in United States have created a distress which has been spread to other nations such as Saudi Arabia. The findings of this study may help in seeing the essence of effects after the financial crisis of 2008 and their effects on stock market in Saudi nation. Through this study investor can understand the nature of stock markets especially during the eras of market instability. Furthermore, deviating towards other markets may help lower risk when markets are experiencing a crisis.

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