TESTING THE CONDITIONAL VOLATILITY OF SAUDI ARABIA STOCK MARKET: SYMMETRIC AND ASYMMETRIC AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY (GARCH) APPROACH

Jumah Ahmad Alzyadat, Dar Aluloom University
Ala’a Adden Abuhommous, Mutah University
Huthaifa Alqaralleh, Mutah University

ABSTRACT

The study aims to investigate the presence of conditional volatility in the Saudi Arabia stock market returns. The daily closing equity market price indices for Saudi stock exchange (Tadawul) covered the period Sep. 2017 to Sep. 2020. The sample was carefully chosen to present only the significant event affecting the stock market, specifically, the COVID-19 pandemic. The study applies the nonlinear GARCH-class models along with the best fitting distribution accounting for the skewness and excess kurtosis in return modeling. The estimation results reveal evidence of an inverted asymmetric effect during the calm time before COVID-19 pandemic. However, strong evidence of news effect was detected as the health crisis began.

Keywords: Saudi Stock Market, Conditional Volatility, GARCH, COVID-19 Pandemic, Stock Market Returns.

INTRODUCTION

The issue of stock market volatility has always been a great importance to financial market participants, researchers and even the public, volatility is often associated with the concept of risk. In the context of a financial crisis, terms such as forecasting volatility or managing risk are among the most important topics in the financial world today. Financial market volatility has historically played a critical role in financial decision-making and volatility forecasts have important applications in areas such as asset pricing, risk management, hedging strategies, and portfolio allocation, as well as forecasting of value at risk (VaR) and optimum capital charges (Miron & Tudor, 2010).

Volatility is one of the most important characteristics of stock markets and financial markets in general. It is directly related to the uncertainty in the market affects the investment decision of institutions and individuals, option pricing, expected future value, and financial market regulation. The study of the volatility of stock returns is also one of the fundamental issues in modern financial economics research; volatility is measured through rate of return variance or standard deviation. Although different models and approaches are available and applied, not all of them work equally with all stock markets or all stocks, so forecasting all market fluctuations is difficult work (Bhowmik & Wang, 2020).

Literature in stock returns and volatility analysis applied autoregressive conditional heteroscedasticity models (ARCH), generalized autoregressive conditional heteroskedastic models (GARCH), Autoregressive Moving Average (ARMA) model, mean absolute deviation (MAD), root mean squared error (RMSE), mean absolute error (MAE), mean squared error.
(MSE), normalized mean squared error (NMSE), Classic historical volatility (VolSD) method. And Exponential smoothing and Exponential weighted moving average (EWMA) model.

Saudi Arabia plays a major role in the oil markets, however not much are known about the Saudi stock exchange market (Tadawul), which is the only stock exchange in the country and the main stock exchange among the countries of the Gulf Cooperation Council. The Saudi stock exchange market was established in 2007; it offers trading of Islamic stocks and bonds known as Sukuk and has nearly 200 companies listed for trading. The Saudi stock market (Tadawul) considered one of the strongest and largest stock markets in the Gulf and the region. During the year 2019, the Saudi Arabian Oil Company (ARAMCO), was listed in the stock market, as the largest listing in the world, as this contributed to deepening the Saudi stock market by increasing the number of companies and increasing trading activity and values. The year 2019 witnessed an increase in the general index of Saudi stock prices by 7.2 percent compared to 2018 (Saudi central bank, 2020). The year 2020 witnessed an increase in the general index of Saudi stock prices by 3.58 percent compared to 2019 (Saudi Stock Exchange, 2020). Therefore, this study aims to investigate the presence of conditional volatility in the Saudi Arabia stock market returns. The latter will be achieved through adopting the nonlinear GARCH-class models along with the best fitting distribution accounting for the skewness and excess kurtosis in return modeling.

LITERATURE REVIEW


Glosten et al. (1993) used the modified GARCH-M model showed that monthly conditional volatility may not be as persistent. Engle, (2001) used ARCH and GARCH models to provide an example of measuring risks that are the input to a variety of economic decisions.

Patev & Kanaryan, (2003) applied GARCH-M (1,1) with Student T distributed errors to investigate the impact of both recent news and old news on the conditional volatility. And applied EGARCH-M (1,1) with GED distributed errors to examine the asymmetric effect in four Central European stock market indexes. Patev et al. (2009) revealed that the EWMA with t-distributed innovations and the EWMA with GED distributed innovations evaluate the risk of the Bulgarian stock market.

Matei et al. (2019) proposed a class of bivariate GARCH models that includes estimates of daily, day and night fluctuations. Models have been experimentally tested to confirm whether using night volatility information improves estimation of daily fluctuations. The results indicated that an improvement in prediction using bivariate GARCH models compared to those that do not include estimates of night fluctuations. Aliev et al. (2020) employed EGARCH and GJR-GARCH to estimate the volatility of nonfinancial, innovative and hi-tech focused stock index, the Nasdaq-100. The study found that the volatility shocks on the index returns are quite persistent. Furthermore, the findings showed that the index has leverage effect, and the impact of shocks is asymmetric, whereby the impacts of negative shocks on volatility are higher than those of positive shocks of the same magnitude.

As for the Saudi financial market, there are many studies that have been carried out to estimate and forecast volatility of Saudi Arabia stock market using daily closing prices on the general market index (Tadawul All Share Index; TASI) used symmetric and asymmetric (GARCH) model. Abdalla (2012) provided strong evidence of the persistence of time varying volatility, the asymmetric GARCH models show a significant evidence for asymmetry in stock returns. Al Freedhi et al. (2012) found that AR(1)-GJR GARCH model with student-t outperform the other models during and before the local crisis (2006), while AR(1)-GARCH model with GED has a better performance after 2006 period. Kalyanaraman (2014) showed that a linear symmetric GARCH (1,1) model is adequate to estimate the volatility of the stock market also;
Saudi stock market returns characterized by volatility clustering and followed a non-normal distribution. Mhmoud & Dawalbait, (2015) showed that the asymmetric GARCH models with a heavy tailed error distribution better than the symmetric GARCH model to estimate and forecast volatility of Saudi stock market. Al Rahahleh & Kao, (2018) suggest that the Asymmetric Power of ARCH (APARCH) model is the most accurate model in the GARCH for forecasting the volatility of both the Tadawul All Share Index (TASI) and the Tadawul Industrial Petrochemical Industries Share Index (TIPISI) for petrochemical industries in the context of petrochemical industries. Shaik & Syeda, (2019) indicated that the symmetric and asymmetric GARCH models are comfortable to capture the Intraday return volatility of Saudi stock market.

Assous et al. (2020) investigated the effectiveness of six of the main international indices in estimating the movement of the Saudi Stock Exchange Index (TASI). The results showed that the SP500, NIKKEI, CAC40 and HSI indices are the most relevant variables for TASI estimation. Kang et al. (2009) investigates the volatility of the three crude oil prices Brent, Dubai, and West Texas Intermediate (WTI) using conditional volatility models. Concluded that the CGARCH and FIGARCH models are useful for modeling and forecasting the volatility of crude oil prices.

**METHODOLOGY**

Investigating the impact of the stylized fact of financial data is a continuing concern within the financial analysis literature especially in the context of transitory shocks to the stock market variables. Traditionally, these stylized have been addressed by the so-called asymmetrical GARCH-type models (Corbet & Katsiampa, 2018; Alqaralleh et al. 2020).

As highlighted to the introduction, the present study looks for fresh insights into the links between the Covid-19 pandemic and the model for testing volatility that is selected. Therefore, the following nonlinear GARCH-class models along with the best fitting distribution accounting for the skewness and excess kurtosis in return modeling are used.

Suppose that a Tadawul stock index returns on day \((r_t)\) and follows a white noise process such as

\[
R_t = \sum_{j=1}^{\theta} \theta_j e_{t-1} + e_t, e_t \equiv NIID(0, \sigma^2) 
\]

\[
e_t = \theta_t \sqrt{\sigma_t}.
\]

Following the seminal work of Hentschel (1995), the news impact in the return can be driven by allowing for both shifts \((\eta_{1j})\) and rotations \((\eta_{2j})\) to account for both small shocks (defined as asymmetry) while rotation drives large shocks.

\[
\sigma^2 = \left(\omega + \sum \zeta_j v_j \right) + \sum \alpha_j \sigma_{t-j}^{\lambda} \left[|z_{t-j} - \eta_{2j}| - \eta_{1j}(z_{t-j} - \eta_{2j})\right]^{\delta} + \sum \beta_j \sigma_{t-j}^{\lambda} \quad (3)
\]

Various sub-models can be obtained from the model in equation 3. Higgins & Bera, (1992) proposed the nonlinear GARCH (NGARCH) model, in which a small shock is not different from large one, i.e. \(\delta=\lambda\). The NARCH model is obtained from equation 3 by setting \(\lambda=\delta=2\) and \(\eta_{1j}=\eta_{2j}=0\).

Ding et al. (1993) present the Asymmetric Power ARCH Model (APARCH) which delivers a general class of volatility models that well reveal Fat tails, Excess kurtosis, the Taylor effect, and Leverage Effects. Such a model as APARCH \((1,1)\) can be expressed by equation 3 by
applying the following conditions $\lambda = \delta$, $\eta_{2j} = 0$ and $|\eta_{1j}| \leq 1$. Among the nonlinear GARCH models, the GJR GARCH (1,1) model introduced by Glosten et al. (1993) can be derived when $\lambda = \delta = 2$ and $\eta_{2j} = 0$. Finally, Engle and Ng, (1993) propose the Nonlinear Asymmetric GARCH (NAGARCH) model in which the rotation parameter is eliminated, $\tau_{2} = 0$ and $\delta = \lambda = 2$.

Following the literature in this regard, the Generalized Hyperbolic Distribution (GHYP) is incorporated to break down the standardizing and estimating density function. As highlighted by Alqaralleh et al. (2020)

“This distribution is introduced to finance as a more realistic model for returns series in Eberlein (2001), Eberlein and Prause (2002).”

DATA AND ESTIMATION RESULTS

The stock market data under consideration have been drawn from the daily closing equity market price indices for Saudi stock exchange (or known as Tadawul) covered the period Sep. 2017 to Sep. 2020. The sample was carefully chosen to present only the significant event affecting the stock market, specifically, the COVID-19 pandemic. It is worth noting that the returns are calculated as the difference between the logarithms of the price index. Further, the missing data are bypassed by assuming them to equal the average of the recorded previous price and the next one.

The descriptive statistics provides evidence that the return series is not only non-normally distributed with higher standard deviation, but also exhibits excessive kurtosis. Therefore, the nonlinear-GARCH models are suitable for modeling the volatility in this case.

For the purpose of this study, the sample was split in two subperiods: the first with $T = 551$ including data from Sep. 20, 2017 to Dec 31, 2019, and the second subperiod including a sample of $T = 167$ including observations from Jan., 2nd 2020 to Sep. 17, 2020. For more robustness, a various type of nonlinear GARCH models and error distributions was adopted to obtain further in-depth information on the Tadawul market behavior. The latter lead to leading to a total of 15 models estimated using a maximum likelihood. A comparison of these models was drawn on AIC (Akaike Information Criterion) and BIC (Bayes information criterion) to evaluate these models. Interestingly, specification results indicated that a GHYP distribution is best fitted specification for the innovation terms in almost all nonlinear GARCH considered in this study. Moreover, evidence suggest that there is a significant autocorrelation in the index return series discovered through the Q-statistic and thus an AR(1), specification was used following Ewing and Malik (2010).

The results obtained from the nonlinear GARCH models are summarized in Table 1 and Table 2 for the time before and during the COVID-19 pandemic, respectively. What stands out in the bottom of these tables is that the validity of the reported results is guaranteed. In specific, the estimated parameters are stable over the time since the null hypothesis of zero variance of the error term is generally not rejected. These Results is further supported by sign bias tests of Engle and Ng, (1993) for misspecification of conditional volatility models that allows testing for the impact of positive and negative shocks on volatility not predicted by the model. In all cases, the nullity is generally not rejected as such there is no evidence that sign of the shocks play an important role in predicting the variable.

Turning to the estimated results, broadly speaking almost all the variables are significant and have the expected sign. Further, it appears that the Tadawul stock return highly persistent since the magnitude of the estimated parameters $\beta$ is relatively high. Similarly, the parameters of
skew and shape (where applicable) are significant. Put in order, Panel A of Table 1 indicate the presence of Taylor effect in the return. Surprisingly, an inverted asymmetric effect was found during this time. This effect can be explained with herding of uninformed investors if prices go up and contrarian behavior of informed investors if prices go down.

Table 1
ESTIMATION NONLINEAR GARCH MODELS FOR THE STICK MARKET INDEXES UNDER CONSIDER BEFORE THE COVID-19 OUTBREAK.

<table>
<thead>
<tr>
<th></th>
<th>NGARCH</th>
<th>NAGARCH</th>
<th>APARCH†</th>
<th>GJR-GARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR(1)</td>
<td>-0.157**</td>
<td>0.046</td>
<td>-0.353**</td>
<td>-0.399**</td>
</tr>
<tr>
<td></td>
<td>-0.038</td>
<td>-0.217</td>
<td>-0.208</td>
<td>-0.239</td>
</tr>
<tr>
<td>MA(1)</td>
<td>0.339**</td>
<td>0.17</td>
<td>0.185*</td>
<td>0.203**</td>
</tr>
<tr>
<td></td>
<td>-0.137</td>
<td>-0.215</td>
<td>-0.027</td>
<td>-0.143</td>
</tr>
<tr>
<td>α</td>
<td>0.284*</td>
<td>0.079**</td>
<td>0.261**</td>
<td>0.053**</td>
</tr>
<tr>
<td></td>
<td>-0.046</td>
<td>-0.039</td>
<td>-0.013</td>
<td>-0.036</td>
</tr>
<tr>
<td>β</td>
<td>0.739**</td>
<td>0.763*</td>
<td>0.723**</td>
<td>0.829*</td>
</tr>
<tr>
<td></td>
<td>-0.24</td>
<td>-0.027</td>
<td>-0.238</td>
<td>-0.019</td>
</tr>
<tr>
<td>γ</td>
<td>0.659</td>
<td>-</td>
<td>0.873*</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-0.78</td>
<td>-</td>
<td>-0.021</td>
<td>-</td>
</tr>
<tr>
<td>δ</td>
<td>-</td>
<td>1.117**</td>
<td>1.024*</td>
<td>0.972</td>
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<tr>
<td></td>
<td>-</td>
<td>-0.603</td>
<td>-0.173</td>
<td>-0.65</td>
</tr>
<tr>
<td>Shape</td>
<td>2.014*</td>
<td>1.533**</td>
<td>-0.084</td>
<td>0.577**</td>
</tr>
<tr>
<td></td>
<td>-0.797</td>
<td>-0.675</td>
<td>-0.077</td>
<td>-0.292</td>
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<tr>
<td>Skew</td>
<td>-0.094*</td>
<td>-0.363</td>
<td>0.868*</td>
<td>-0.771</td>
</tr>
<tr>
<td></td>
<td>-0.012</td>
<td>-0.854</td>
<td>-0.036</td>
<td>-2.92</td>
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</table>

Information Criterion

<table>
<thead>
<tr>
<th></th>
<th>Akaike</th>
<th>Bayes</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>-8.452</td>
<td>-8.492</td>
</tr>
<tr>
<td></td>
<td>-8.943</td>
<td>-8.495</td>
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<td>-8.374</td>
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<tr>
<td></td>
<td>-8.873</td>
<td>-8.417</td>
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</table>

Misspecification

<table>
<thead>
<tr>
<th></th>
<th>ARCH Lag[P] P</th>
<th>[0.285]</th>
<th>[0.346]</th>
<th>[0.621]</th>
<th>[0.642]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weighted Ljung-Box P</td>
<td>[0.129]</td>
<td>[0.574]</td>
<td>[0.435]</td>
<td>[0.272]</td>
</tr>
<tr>
<td>Nyblom stability test</td>
<td>5.592</td>
<td>[0.281]</td>
<td>[0.465]</td>
<td>[0.495]</td>
<td></td>
</tr>
<tr>
<td>Sign Bias Test P</td>
<td>(0.180)</td>
<td>[0.281]</td>
<td>[0.465]</td>
<td>[0.495]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Stat. between [] refer to p-values, † indicate the best fitted model as suggested by the information criterion. Sign. codes: *' 1%, **' 5%, ***' 10%.

The picture is changed during the COVID-19, in which NGARCH with a GHYP is the best fitted model, suggesting that the return series have a semi-heavy tail (introduce heavier tails and skewness) and, thus highly prone to news effect. Results in Panel A of Table 2 implies that the Covid-19 outbreak increased persistence in the stock market since the estimated parameters β is greater in magnitude than the one in Table 1. Moreover, the leverage term (γ) are negative during this pandemic time, suggesting an unequal response to market innovations. That is to say, a positive return has less influence on future volatility than do negative returns.

Table 2
ESTIMATION NONLINEAR GARCH MODELS FOR THE STICK MARKET INDEXES CONSIDER DURING THE COVID-19 OUTBREAK.

<table>
<thead>
<tr>
<th></th>
<th>NGARCH</th>
<th>NAGARCH†</th>
<th>APARCH</th>
<th>GJR-GARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR(1)</td>
<td>-0.596*</td>
<td>-0.560*</td>
<td>-0.596*</td>
<td>-0.603*</td>
</tr>
<tr>
<td></td>
<td>-0.013</td>
<td>-0.091</td>
<td>-0.087</td>
<td>-0.093</td>
</tr>
<tr>
<td>MA(1)</td>
<td>0.717*</td>
<td>0.693*</td>
<td>0.716*</td>
<td>0.720*</td>
</tr>
<tr>
<td></td>
<td>-0.014</td>
<td>-0.076</td>
<td>-0.075</td>
<td>-0.077</td>
</tr>
</tbody>
</table>
CONCLUSION

In this study, we investigate the presence of conditional volatility in the Saudi Arabia stock market returns. The main novelty of our paper lies in distinguishing between regular time and during the Covid-19 pandemic. In other words, we show how the stock market return prone to news effect. To this end, the stock market data under consideration have been drawn from the daily closing equity market price indices for Saudi stock exchange (or known as Tadawul) covered the period Sep. 2017 to Sep. 2020. The sample was carefully chosen to present only the significant event affecting the stock market, specifically, the COVID-19 pandemic. The estimation results reveal evidence of an inverted asymmetric effect during the calm time before COVID-19 pandemic. However, strong evidence of news effect was detected as the health crisis began.

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