Investigating Short and Long Run Volatility Movements in the Context of COVID-19 Pandemic: A Case Study for Norwegian Stock Market

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Abstract

The main aim of this empirical study is to examine short and long run volatility movements based on a case study for Norwegian Stock Market, i.e. Oslo Stock Exchange. The econometric framework includes a series of statistical tests, ARIMA models and GARCH family models for the sample period from March 2013 to October 2021. The empirical results were influenced by the impact of COVID-19 pandemic. This research paper also contributes to the existing literature regarding the influence of extreme events, such as COVID-19 pandemic on the behavior of developed stock markets, like Norwegian Stock Market.

Key words: ARIMA models, leverage effect, GARCH models, volatility, COVID-19 pandemic, stock market behavior
J.E.L. classification: D53, E44, G1, G4

1. Introduction

We focus on modeling changes in volatility pattern for OSEAX index from the OSLO BORS which is the Norwegian stock exchange considering data range from March 2013 to October 2021. ARIMA and GARCH class models have been used to lead volatility clusters from the series returns. The article focuses to model short and long volatility shocks, impact of COVID-19 pandemic and demonstrates fitness of GARCH and ARIMA class models to series returns.

The empirical findings revealed that ARIMA model with standard errors is not fitted, while GARCH (1, 1) model is fitted at significance level of 1%. The empirical results also confirmed the existence of short and long run volatility which were found and have been presented in graphical manner, while the stock return series have revealed the presence of leverage effect. Moreover, the EGARCH (1, 1) model conditional mean equation does not provide any significant to selected stock return series.

The World Health Organization known especially under the acronym WHO made an official statement defining the novel Coronavirus or COVID-19 as a "public health emergency of international concern" (WHO 2020). Moreover, starting with the official date of 11 March 2020, as a direct consequence of the extremely rapid spread everywhere in almost every country in the world, the World Health Organization stated that COVID-19 represents a global pandemic due to its extremely fast spreading capacity worldwide, but also considering its disastrous global consequences.

2. Literature review

Mou (2020) consider that the COVID-19 pandemic will remodel the macroenvironment of the world economy in terms of aggregate demand and total supply, labor income, and financial market trade. Hayat et al. (2021) highlighted the fact that COVID-19 pandemic has negatively influenced most economies in the world, even more so in the context severe measures implemented by governmental authorities based on enforced lockdowns and social distancing. Varona and Gonzales (2021) suggested that developing countries experience the impact of COVID-19 pandemic in a much amplifed way, even at doubled intensity, i.e.: an external shock and an internal shock which influence both aggregate supply and demand.

Ejaz et al. (2020) examined the behavior of Toronto stock exchange in the context of domestic portfolio diversification strategies, and pointed out that emerging stock markets ensure higher global investment opportunities compared to developed stock markets, such as Canada. Spulbar et al. (2019) have conducted an empirical study in order to examine the volatility effect, causality and financial contagion in case of a selected cluster including developed stock markets such as: USA, Canada, France and UK. The econometric framework was based on several statistic test such as: Unit Root Test, ADF test, Granger causality test and Vector Auto Regression (VAR), but also included GARCH (1, 1) model for the sample period from January 2000 until June 2018.

Davi et al. (2013) examined the ARIMA model and highlighted a number of advantages regarding the accuracy of the results provided in the forecasting process by using this algorithmic framework. On the other hand, it is important to mention that Wadia et al. (2011) provided a more critical approach regarding ARIMA model highlighting certain limitations such as its more precise applicability, especially in terms of time series/sequential data.

ARIMA stands for acronym of Auto-Regressive Integrated Moving Average model which in terms of the internationally academic and research community represents a generalization of another model, such as Autoregressive Moving Average (ARMA) model. Meher et al. (2021) highlighted the importance of including certain AR and MA terms in order to increase the significance of the model.

Fiskerstrand et al. (2020) examined the impact of ESG factors, such as environmental, social and corporate governance on the financial performance of the stock market in Norway for the sample period from 2009 to 2018. The empirical findings revealed there is no linkage between ESG factors and the dynamics of financial stock returns in the case of Norwegian stock market. Meher et al. (2020) revealed the fact that sustainable investment is interconnected with the ESG factors, which are environment, society and corporate governance considering that a sustainable stock market should focus on ensuring transparency and efficient responses in this regards.

3. Research methodology

The research methodology is based on financial econometric framework. In order to proceed with the econometric approach, we considered OSEAX index as the Oslo Bors All-Share Index for the sample period from March 2013 to October 2021, daily closing price databases. The sample period consists of 2155 daily observations.

We employ the following tests/models to investigate the normality of selected stock returns, clustering effect, presence of leverage effect and fitness of returns using the following econometric tools: ADF, ARIMA model, GARCH (1, 1) model and Exponential GARCH (1, 1) model.

The continuously-compounded daily returns is determined using the log-difference of selected stock market index, such as OSEAX index, as follows:

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \ln(p_t) - \ln(p_{t-1})$$

ADF regression process is managed as follows :

$$\Delta y_t = c + \beta \cdot t + \delta \cdot y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t$$

ADF process is managed as follows :

$$(1-L)yt = \beta 0 + (\alpha - 1)yt - 1 + \varepsilon i$$

Symmetric GARCH (1, 1) model is used as the following:

$$h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$$

Generalized Autoregressive Conditional Heteroscedastic or GARCH model is a generalized version of ARCH model designed by Engle. GARCH (1, 1) processes 1 ARCH effect and 1 GARCH effect. Processing Mean and Variance equations;

Mean equation is used as the following:

$$rt = \mu + \varepsilon t$$

Mean equation indicates sum of average return denoted by (μ) that is returns of asset in time (t), and residual return denoted by (εt).

Variance equation is used as the following:

$$\sigma_t^2 = \omega + \alpha \varepsilon_{1t-t}^2 + \beta \sigma_{1\,t-1}^2$$

The variance equation is based on the assumption that the value of constant is higher than 0, considering the value of $\alpha + \beta$.

The GARCH (1, 1) model represents a symmetric model that is extensively used to estimate volatility in time series returns.

The EGARCH model is also called Exponential GARCH model. EGARCH model has been developed by Nelson in 1991. It captures asymmetric responses of time-vary variances to volatilty shocks and also ensures that variance is always positive.

$$Log(\sigma_t^2) = \omega + \sum_{j-i}^{p} \beta i \; Log(\sigma_{t-i}^2) + \sum_{j-1}^{q} \alpha i \left\langle \frac{\varepsilon\, i-t}{\sigma}_{i-t} \left| - \frac{\sqrt{2}}{n} \right| - yi \frac{\varepsilon\, i-t}{\sigma\, i-t} \right\rangle$$

ARIMA model is the following:

$$\hat{y}_t = \mu + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q}$$

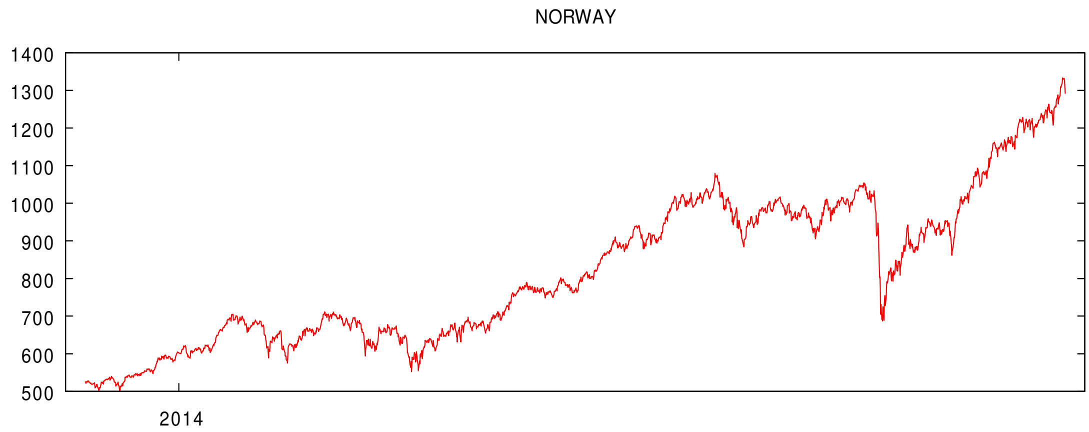
Moreover, the moving average parameters (θ's) are defined so that their signs are negative in the equation, the parameters are denoted there by AR(1), AR(2), …, and MA(1), MA(2).

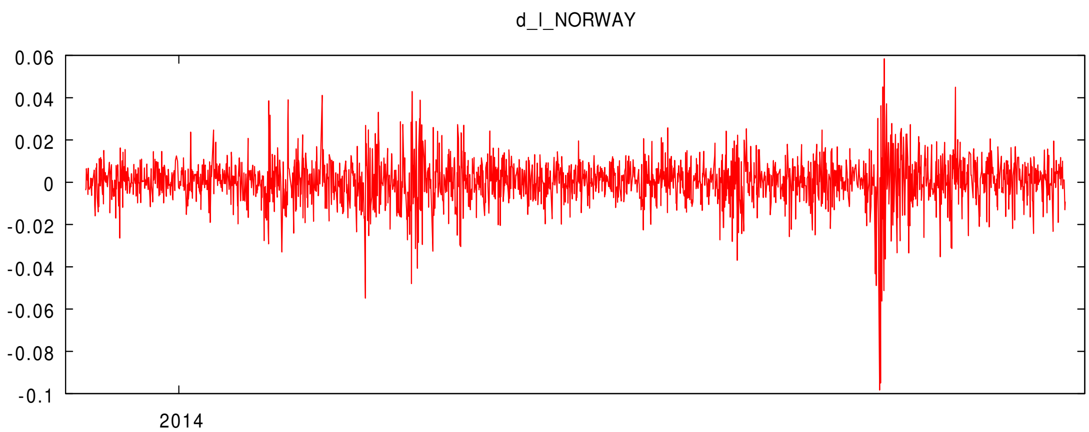
4. Findings

The Augmented Dickey-Fuller test was applied for OSEAX index of Norwegian stock market for the selected time period from March 2013 to October 2021. The empirical analysis was testing down from 25 lags, criterion AIC considering sample size 2146 - test with constant and using model: (1-L)y = b0 + (a-1)*y(-1) + ... + e, indicates estimated value of (a - 1): -0.941118 where test statistic: tau_c(1) = -15.6839., while with constant and trend estimated value of (a - 1): -0.941382 and test statistic: tau_ct(1) = -15.6816.

Figure no.1 indicates actual series movement from March 2013 to October 2021 consisting in 2155 daily closing index. Series movement captures the growth of OSEAX index from OSLO BORS from trading level of 500 to exceeding over 1000 before the impact of COVID – 19 pandemic, which resulted index to trend below more than 25% of pre-COVID-19 pandemic trading level. The recovery of index appears sharp and aggressive for the selected time period. The volatility magnitude appears in Fig. no.1 reaching to -0.10 magnitudes.

Figure no. 1 The trend of OSEAX index series returns (closing price actual movement and normalized log-returns)





Source: Authors' computation

Table no. 1 Summary Statistics

Mean	Median	Minimum	Maximum
0.00041818	0.00074757	-0.098320	0.058424
Std. Dev.	C.V.	Skewness	Ex. kurtosis
0.010789	25.801	-0.90427	8.5409
5% Perc.	95% Perc.	IQ range	Missing obs.
-0.016404	0.016063	0.010985	1

Source: Authors' computation

Property of summary of statistics indicates that index consists least but positive mean returns which negatively skewed and found with excess kurtosis, creating leptokurtic impact.

Table no. 2 ARMA model results

	Coefficient	std. error	z	p-value	
const	0.000418354	0.000225869	1.852	0.0640	*
phi_1	−0.0275634	0.349367	−0.07890	0.9371	
theta_1	−0.000995630	0.348983	−0.002853	0.9977	

Mean dependent var	0.000418	S.D. dependent var	0.010789
Mean of innovations	−5.27e-08	S.D. of innovations	0.010782
Log-likelihood	6700.881	Akaike criterion	−13393.76
Schwarz criterion	−13371.06	Hannan-Quinn	−13385.46

	Real	Imaginary	Modulus	Frequency
ARRoot 1	-36.2800	0.0000	36.2800	0.5000
MARoot 1	1004.3887	0.0000	1004.3887	0.0000

Source: Authors’ computation

Table no. 3 The empirical results for GARCH (1,1) and EGARCH (Normal) models

Conditional mean equation

	coefficient	std. error	z	p-value	
const	0.000564863	0.000177114	3.189	0.0014	***

Conditional variance equation

	coefficient	std. error	z	p-value	
omega	3.40524e-06	1.29107e-06	2.638	0.0084	***
alpha	0.106881	0.0245965	4.345	1.39e-05	***
beta	0.861962	0.0328564	26.23	1.08e-151	***

EGARCH (1, 1)
Conditional variance equation

omega	-0.336523	0.0741525	-4.538	5.67e-06	***
alpha	0.112883	0.0250949	4.498	6.85e-06	***
gamma	-0.131845	0.0164773	-8.002	1.23e-015	***
beta	0.973304	0.00649304	149.9	0.0000	***

Llik: 7003.10167 AIC: -13998.20334
BIC: -13975.50301 HQC: -13989.89951

Source: Authors’ computation

GARCH (1, 1) model fitted well to Norway series returns, the results from ARIMA is not satisfactory and significant along with conditional mean equation returns from EGARCH (1, 1) from the selected data range. We found that considering significant of Norway series returns by testing normality using ADF before applying ARIMA/GARCH modelling. The result property of ARIMA indicates significant at 10% returns only from the constant. Thus, ARMA model is not suitable for selected time returns. GARCH (1, 1) suitable for fitness of statistics, Exponential GARCH (1, 1) fitted only to conditional variance equations at significant level of (1%) but not to mean equations. It indicates presence of leverage effect, suggesting that negative volatility shocks creates more volatility than the positive shocks.

5. Conclusions

This research paper provides additional evidence on stock market behavior. We used ARMA and GARCH class models to capture the changes in volatility from Norway financial market series returns. Summary of descriptive statistics indicates that returns are negatively skewed with higher degree of kurtosis (leptokurtic) returns, ARMA model did not fitted to selected data and time range. GARCH class models (Bollerslev) GARCH (1, 1) fitted at significance level of 1%, Exponential GARCH fitted only to variance equations, and captures presence of leverage effect. The changes in market movement pattern and short and long run volatility including the impact of COVID-19 pandemic were captured.

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