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Forecasting the Banque Pour Le Commerce Exterieur Lao Public Stock' Return During the Covid-19 Pandemic Using the Box-Jenkins Approach

Phetdavanh DOUANGVILAYKEO*

Major of Management Science and Engineering, Faculty of Management and Economics, Kunming University of Science and Technology

Corresponding Author:
Phetdavanh DOUANGVILAYKEO, Major of Management Science and Engineering, Faculty of Management and Economics, Kunming University of Science and Technology, Yunnan Province, China.
Tel: +856-20 2866 3466, +8613211706760, E-mail: Phet88.lpb@gmail.com

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Abstract

The Box-Jenkins Model or Autoregressive Integrated Moving Average (ARIMA) is one of the technical analyses that widely used. Therefore, this paper aims to predicting the return of Banque Pour Le Commerce Exterieur Lao Public (BCEL) stock through Box-Jenkins's approach by using a time series of daily closed price of BCEL stock during the Covid-19 Pandemic from January 3, 2020 to August 16, 2021 (excluded any holidays such as Lao New Year, National Day, Women's Day, etc.) to analysis. According to the technical analysis by using Box-Jenkins's approach indicated that an appropriate model for predict the rate of return of BCEL stock was ARMA (1,3) model due to it has more coefficients significant, highest log likelihood, lowest volatility, lowest AIC and BIC respectively. In practical, the rate of return of stock does not only depend on its lag order and the error term but also depend on policy, economic factors and industrial factors thus making the forecasting more effectiveness ahead, therefore further predictor should consider the method most appropriate to the data and the situation of predicting.

Keyword: *Stock Price, ARIMA, Box-Jenkins.*

1. Introduction

The impact of Covid-19 Pandemic effect on all countries around the world including Lao PDR. In quarter 1 of 2020 the stock exchange around the world affected from COVID-19 leaded to Lao Securities Exchange (LSX) fluctuated and went down for 13.61% but trading value was increasing comparing to the same quarter of previous year as the figure 1. The deceased stock price affected to LSX index deceased. Moreover, the total listed share market capitalization and tradable share market capitalization (which was 27.17% of total listed share market capitalization) decreased all together.

Banque Pour Le Commerce Exterieur Lao Public (BCEL) is one of the stocks there is changing almost every day, it was attractive stock for investor trading which accompanied ratio for 89.30% of total trading in trading hours. For others stocks summed up trading were only 10.70% of total trading. Therefore, it attracted researcher to analyze and predict the stock price changing or return during the Covid-19 Pandemic due to this evidence has never been studied before.

Based on the literature reviews found that there are many researchers using Box-Jenkins's Approach to predict the stock exchange or stock returns such as Nuzula (2019), Mohamed, S.B & Abdurrahman, B. (2020), Mulukalapally,S. (2017), Boye, P. and Ziggah, Y. (2020), A. Khamis et al (2018) and S. Nanda (1988) but in the evidence of Lao PDR there have ever studied before especially case of BCEL stock. Box and Jenkins (1970) method, named after the statisticians George Box and Gwilym Jenkins, applies autoregressive moving average (ARMA) or autoregressive integrated moving average (ARIMA) models to find the best fit of a time-series model to past values of a time series. The Box-Jenkins Model is a mathematical model designed to forecast data ranges based on inputs from a specified time series. The Box-Jenkins method is allowed a good deal of freedom of choice and correspondingly, is require various stages for procedure to exercise judgement in the choice of appropriate forecast model.

With above reasons motivated researcher to use Box-Jenkins's method to try with the case of BCEL stock during the Covid-19 Pandemic. The outcomes of this paper maybe useful for most of readers and investor whom would like to try predict the stock returns. Therefore, the objective of this study is forecasting the return of BCEL stock.

2. Materials and Methods

This paper researcher used a daily stock closed price of BCEL from January 3, 2020 to August 16, 2021 (excluded any holidays such as Lao New Year, National Day, Women's Day, etc.) which the time series of daily closed price of BCEL stock was transformed into daily return by the log transformation of return as following.

$$R_t = Ln(\frac{P_{t+1}}{P_t}) \quad (1)$$

R_t: the rate of return of BCEL stock at time t

P_t: the closed price of BCEL stock at time t

On forecasting it was implied by Box and Jenkins (1970) methodology to select appropriate models for estimating and forecasting univariate models. Box and Jenkins three stages are identification, estimation and diagnostic and forecasting. The ARMA (autoregressive, moving average) model is defined as follows:

$$\Delta R_t = \delta + \emptyset \Delta R_{t-1} + \cdots + \emptyset \Delta R_{t-p} + u_t - \theta_1 u_{t-1} - \cdots - \theta_q u_{t-q} \quad (2)$$

Where, R_t : the BCEL Stock Price Return in the period t

t : time

Δ : the differences of the time series.

p : the lag of Autoregressive

q : the lag of Moving Average

δ : Constant term

$\emptyset_1 ... \emptyset_p$: Parameters of Autoregressive

$\theta_1 ... \theta_q$: Parameters of Moving Average

u_t : residuals

Box-Jenkins use the backshift operator to make writing these models easier. The backshift operator, B, has the effect of changing time period t to time period t-1. Thus, $BX_t = X_{t-1}$ and $B^2X_t = X_{t-2}$. Using this backshift notation, the above model may be rewritten as:

$$\left(1 - \emptyset_1 B - \cdots - \emptyset_p B^p\right) X_t = (1 - \theta_1 B - \cdots - \theta_q B^q)\alpha_t \quad (3)$$

This may be abbreviated even further by writing:

$$\emptyset_p(B) X_t = \theta_q(B)\alpha_t \quad (4)$$

Where, $\emptyset_p(B) = (1 - B - \cdots - \emptyset_p B^p)$ and $\theta_q(B) = (1 - B - \cdots - \theta_q B^q)$

These formulas show that the operators $\emptyset_p(B)$and $\emptyset_p(B)$ are polynomials in B of orders p and q respectively. One of the benefits of writing models in this fashion is that we can see why several models may be equivalent.

2.1 Unit Root Test

In order to avoid the inconstant mean and variances of data at different times, the unit root testing is used to check if the data is stationary [I(0); integrated of order 0] or non-stationary [I(d); , integrated of ordered] by considering the Augmented Dickey – Fuller (ADF) test statistics at the 1%, 5%, and 10% level of significance respectively. Lagged change of ADF test can be written as:

$$\Delta X_t = \alpha + \beta_t + \gamma X_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta X_{t-i} + \varepsilon_t \quad (4)$$

Where, X_t: series at time t

X_{t-1}: series at time t-1

$\alpha, \beta, \gamma, \varphi$: parameters

ε_t: error term

Hypothesis:

H_0: $\gamma = 0$ the series is non-stationary

H_1: $|\gamma| < 0$ the series is stationary

2.2 The Accuracy Analysis of the Forecast

To decide which model good fitted the researchers will use the criteria of log likelihood, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF), written as:

1) Likelihood Function

$$L_t(y_t, x_t, \tau) = \prod_{t=1}^{T} L_t(y_t, x_t, \tau) \quad (5)$$

where L_t is the (exact) likelihood function for observation t

$$L_t(y_t, x_t, \tau) = f_{Y_t|X_t(y_t|x_t,\tau)\times f_{X_t}(x_t)} \quad (6)$$

Accordingly, the exact likelihood function is given by

$$L(y, x, \tau) = \prod_{t=1}^{T} f_{Y_t|X_t}(y_t|x_t, \tau) \quad (7)$$

The conditional log-likelihood function is then given by

$$L(y|x, \tau) = -\frac{T}{2}\log(\sigma^2) - \frac{T}{2}\log(2\pi) - \frac{1}{2\sigma_t^2}\sum_{t=1}^{T}(y_t - x_t'\beta)^2 \text{ (8}$$

2) Autocorrelation Function (ACF)

It is a function measuring the correlation between data at time $t(x_t)$ and data at $t - k\ (x_{t-k})$ of k intervals which represented by r_k and can be written as following:

$$r_k = \frac{\sum_{t=k+1}^{n}(x_t - \bar{x})(x_{t-k} - \bar{x})}{\sum_{t=1}^{n}(x_t - \bar{x})^2} \quad (9)$$

And the Box-Pierce Q-Statistics

$$Q = n\sum_{k=1}^{m} r^2 \sim \chi^2(m - p - q)$$

3) Partial Autocorrelation Function (PACF)

Considering the relationship between the variables x_t and x_{t-k}, it is possible that correlation is the result of the correlation ship between the variables $x_{t-1}, \dots, x_{t-k+1}$ which can be written as following:

$$R_{kk} = \frac{Cov[(x_t - \widehat{x_t}), (x_{t-k} - \widehat{x_{t-k}})]}{\sqrt{Var(x_t - \widehat{x_t})}\sqrt{Var(x_{t-k} - \widehat{x_{t-k}})}} \quad (10)$$

Where R_{kk} : the partial autocorrelation and $\widehat{x_t} = \beta_1 x_{t-1} + \cdots + \beta_k x_{t-1+k}$

2.3 White Noise Test

The Box–Pierce portmanteau (or Q) test, developed in 1970, may be applied to a univariate time series, and is often considered to be a general test for 'white noise'. The test implemented by that command is the refinement proposed by Ljung and Box (1978), implementing a small-sample correction. The formulation for the Ljung-Box statistic is

$$Q = N(N + 2)\sum_{k=1}^{h}\frac{\widehat{p_k}^2}{N - k} \quad (11)$$

Where, N indicates the number of the observations, the autocorrelation order of lag is denoted by $\widehat{p_k}$. The number of lags to be tested is indicated by k and h.

However, if the portmanteau test is applied to a set of regression residuals, the regressors in the model are assumed to be strictly exogenous and homoscedastic. A process a_t is called a white noise process if it is a sequence of uncorrelated random variables from a fixed distribution with constant mean,$E(a_t) = \mu_a$, usually assumed to be zero, constant variance,$Var(a_t) = \sigma_a^2$ and $\gamma k = Cov(a_t, a_{t+k}) = 0$, for all $k \neq 0$. It is denoted by $a_t \sim White\ Noise(0, \sigma_a^2)$, where WN stands for white noise. By definition, a white noise process $a_t$is stationary with autocovariance function,

$$\gamma k = \begin{cases} \sigma_a^2, k = 0 \\ 0, k \neq 0 \end{cases}$$

The autocorrelation function is given as:

$$\rho_k = \begin{cases} 1, k = 0 \\ 0, k \neq 0 \end{cases}$$

while the partial autocorrelation function is

$$\varphi_{kk} = \begin{cases} 1, k = 0 \\ 0, k \neq 0 \end{cases}$$

Thus, the implication of a white noise specification is that the ACF and PACF are identically equal to zero.

Hypothesis: H_0: residuals are white noise

H_1: residuals are not white noise

If the residuals are white noise a researcher will use a roots method [Juan D'Amico, 2021] to solve this problem which has the condition likes, if the ARMA process is stationary, AR and MA roots lie inside the unit circle and if the ARMA process is non-stationary, AR and MA roots lie outside the unit circle.

3. Results

3.1 Identification

Based on the theoretical before forecast-ting by Box-Jenkins's approach or ARIMA model, the properties of our variable should be stationary, meaning that a series is covariance stationary therefore I have to plot the series as figure 2.

The figure 2 above it is found that the series is stationary, but to make sure I used the Augmented Dickey Fuller (ADF) test to check, indicated that we can reject null hypothesis because MacKinnon approximate p-value for z(t) was less than the critical value, meaning that the stock return (R) is stationary at the 5% level of statistically without trend and constant as the table 1.

From the result of table 1 expressed that time series is stationary therefore the ARMA model was used to predict, so investigator continue to determine the value of p,q by checking the correlogram of the Autocorrelation Function (ACF) and the partial Autocorrelation Function (PACF) and result in.

The figure 3 seen that AFC was higher than the critical line at lag (1), lag (3) and lag (18) respectively at 95% confidence level. Suggesting that we should try MA (1) and MA (3) due to MA (18) is not flat mean that some information must be captured. However, MA (18) can be considered if it is insignificant.

For PACF in figure 4, suggesting that we should try including AR (1), AR (2), AR (3) and AR (4) because all these lags were higher than the critical line.

3.2 The Estimation

For the Model's selection criteria, I tried testing with any lags as the outcome of ACF and PACF such as ARMA (1,1), ARMA (2,1), ARMA (3,1), ARMA (4,1), ARMA (4,3), ARMA (3,3) and ARMA (1,3) respectively and shown that the value of AIC and BIC of ARMA (1,3) is lower than other models. Moreover, there are more variables statistically significant. Therefore, I concluded that the ARMA (1,3) model is an appropriate model for forecasting the rate of return of BCEL stock during the Covid-19 Pandemic and written as following:

$$\hat{R}_t = -0.0001 - 0.239R_{t-1} - 0.387u_{t-1} + 0.269u_{t-2} - 0.512u_{t-3} \qquad (12)$$

$$(>0.806) \quad (<0.021)^{**} \quad (<0.002)^{*} \quad (<0.000)^{*} \quad (<0.000)^{*}$$

Note: The number in the parenesis is the p-value and *,**,*** indicated it is significant at 1%, 5% and 10% level respectively.

As the results of the equation, it indicated that lag order of rate of return has negative significant on itself, if lag order value of return was increased by 1 unit and effecting on the return at present time decreased by 0.239 unit at the statistically 5% level. But the MA has both positive and negative significant on the rate return of BCEL stock which lag (1) and lag (3) have negative effect, meaning that if the MA increase 1 unit effect the rate of return of BCEL stock decrease by 0.387 and 0.512 units respectively. However, it has positive effect at the lag (2), meaning that if the MA at this lag order increase 1 unit effecting the rate of return of BCEL stock increase by 0.269 unit. the reason causes fluctuated derived from the Covid-19 Pandemic impact on the foreign fund inflows into Lao Securities Exchange Market (LSX) and the revenue or dividend of the BCEL decreased accordingly.

3.3 Diagnostic Testing

To ensure above model perfect resear-chers tried to check the fluctuated of the resi-dual, found that the mean equal to -0.0001885 which very near to zero meaning that it is good, shown as the figure 5 the researchers have been checked the white noise problem by Box-Pierce Portmanteau test or Q-test (1978) found that the p-value= 0.9870, higher than the 5% level of statistical conclude that we cannot reject null hypothesis, meaning that the residual are white noise, therefore investigators solved this problem by AR roots and MA roots, result in figure 6 and it expressed that AR roots and MA roots lie inside the unit circle, it confirms that covariance is stationary and satisfied thus we can forecast the rate of return of BCEL stock by

ARMA (1,3) model.

3.4 Forecasting

For forecasting (figure 7), it shown that the actual value and the forecasting value are closely as the outcome of the table 2. Thus, researcher check the accuracy of the ARMA (1,3) or ARIMA (1,0,3) model by comparing the forecasted return versus the actual returns value was slightly closed especially on February 24,2020 which the actual value is 0.00 and forecast value is 0.00001 although it was affected by Covid-19.

4. Discussion

The technical analysis by Box-Jenkins's approach results in forecasting effectiveness therefore ARMA model useful for investor aligned the study of Nuzula (2019) that used the approach of Box-Jenkins for predicting stock price on LQ45 stock index in Indonesia. He found that ARIMA model successfully forecast LQ45 stock index. Sedat Yenice (2015) have used ARIMA model to forecast the prospective daily closing values of the stock indexes of Turkey, Brazil, Indonesia, South Africa, and India and results in, the closing values forecas-ted via the created models and the actual closes were compared, and the following was realized: The model created for Turkey forecasted with an accuracy rate of approxi-mately 72%; that created for Brazil forecast-ted with an accuracy rate of approximately 65%; that created for Indonesia forecasted with an accuracy rate of approxi-mately 74%; that created for South Africa forecasted with an accuracy rate of approximately 66%; and that created for India forecasted with an accuracy rate of approximately 59%. Furthermore, Mulukala-pally,S. (2017) also used Box-Jenkins Methodology with reference to the Indian Stock Market and results obtained reveal the superiority of ARIMA model over simpler time series methods by using Mean Absolute Percentage Error (MAPE). Boye, P. and Ziggah, Y. (2020) studies on a short-term stock exchange prediction model using Box-Jenkins Approach and found that ARIMA (0, 2, 1) model was fitted for forecasting for a period of six months and the forecasted values showed a significant increase in the Ghana stock exchange performance for the next six months. M.S.Boudrioua (2020) created modeling and forecasting the Algiers Stock Exchange returns using the Box-Jenkins methodology, resulted there are the Seasonal Autoregressive Integrated Moving Average SARIMA (2,0,0) (0,0,1) is chosen as the best model for forecasting the monthly of the Algiers Stock Exchange returns Index which the forecast of the monthly returns for one year ahead using this model shows a decreasing fluctuations trend. Based on different measures of forecast accuracy such as ME, MAE, RMSE, MASE, we show that the forecast accuracy is acceptable and this model performs much better than a naïve model indicated that it could be used by the financial communities in Algeria to deal with stock exchange risks and to improve their decisions. Porcharoen (2021) also used ARIMA model on forecasting stock prices in the information and communication technology sector and found that ARIMA (4,1,4) was an appropriate model to predict the stock price. In addition, A. Khamis et al (2018) have been comparative on forecasting by three models which are namely: Autoregressive Integrated Moving Average (ARIMA), Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH). It was found that ARIMA (2, 1, 5) performed better compared to ARCH and GARCH models to forecast the Crude Palm Oil Price in Malaysia.

However, S. Nanda (1988) suggested that the Box-Jenkins method did not perform as well as the regression method. A lagged linear model proved better than the Box-Jenkins method which examines simultaneously various combinations of the underlying factors. Borivoj Groda et al (2017) have been prediction of stock price developments (Prague Stock Exchange, Czech Republic) using the Box-Jenkins method and it was confirmed that the calculation was done correctly, but with little accuracy therefore the Box-Jenkins method is not a suitable tool for prediction. According this controversial, model builders should choose the method most appropriate to the data and the situation.

5. Conclusion

Based on the empirical analysis by using Box-Jenkins's approach indicated that an appropriate model for predict the rate of return of BCEL stock was ARMA (1,3) model due to it has more coefficients significant, highest log likelihood, lowest volatility, lowest AIC and BIC respectively. The forecasting value nearly the actual value was on February 24, 2020 which the actual value is 0.00 and forecast value is 0.00001. In practical, the rate of return of stock does not only depend on its lag order and the error term but also depend on policy, economic factors and industrial factors thus making the forecasting more effectiveness ahead, therefore further predictor should consider the method most appropriate to the data and the situation of predicting.

6. Conflict of Interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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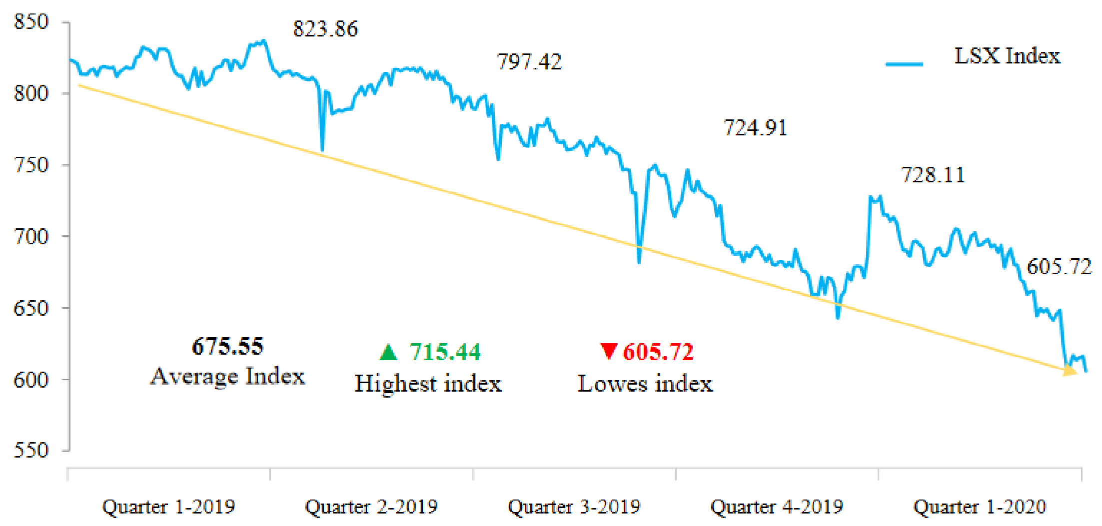

Figure 1. LSX Index

Source: Annual Report of Lao Securities Exchange, 2020.

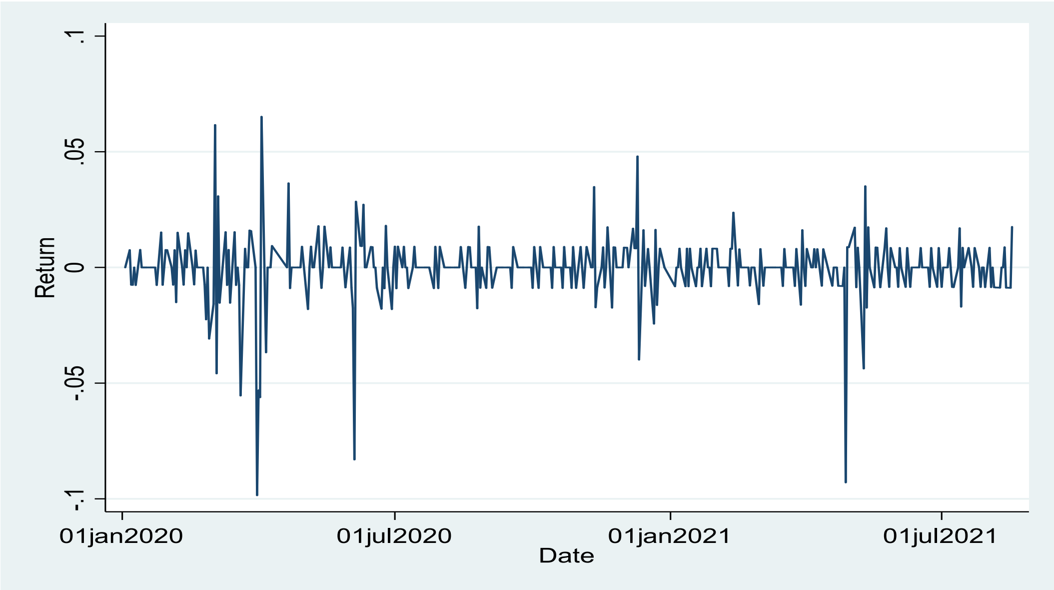

Figure 2. The Daily Rate of Return Volatility

Table 1. Dickey-Fuller test for unit root

	Test Statistic	Critical Value		
		1%	5%	10%
Z(t)	-20.065	-3.987	-3.427	
MacKinnon approximate p-value for Z(t) = 0.0000				
D.R	Coef.	Std. Err	t	P>|t|
R L1.	-1.17181	0.0583	-20.07	0.000
_trend	5.40e-06	4.93e-06	1.10	0.274
_Cons	-0.00176	0.0017	-1.05	0.295

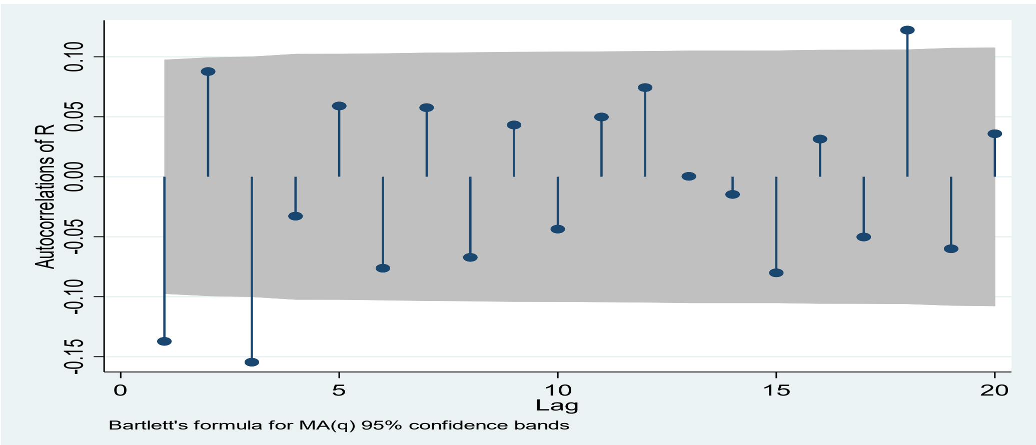

Figure 3. Autocorrelation

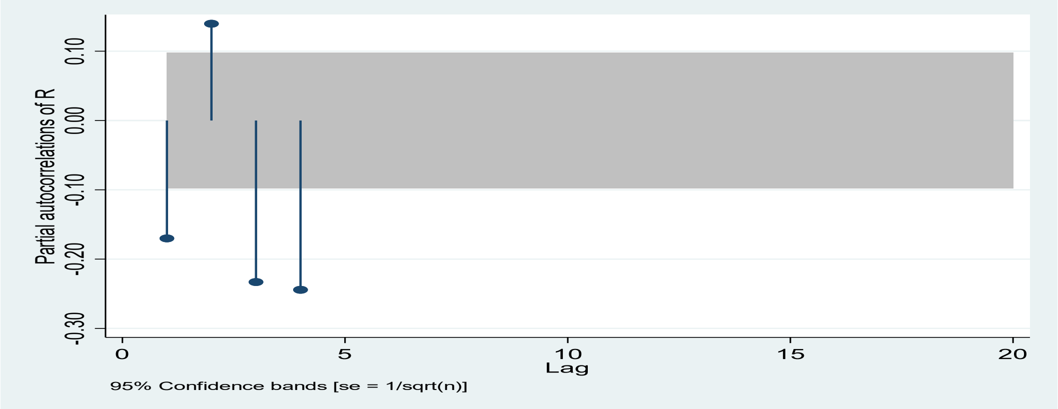

Figure 4. Partial Autocorrelation

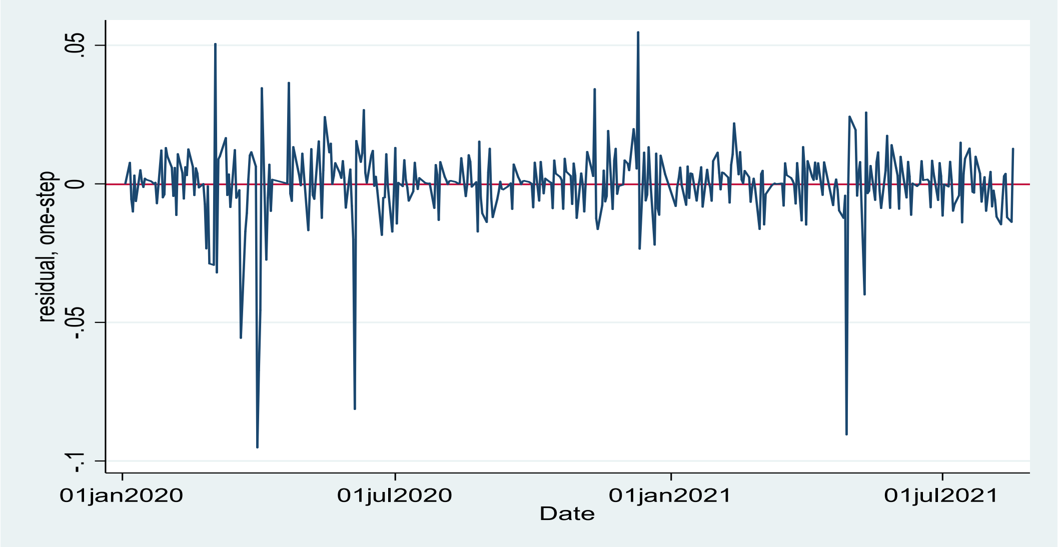

Figure 5. Residual of the Estimation

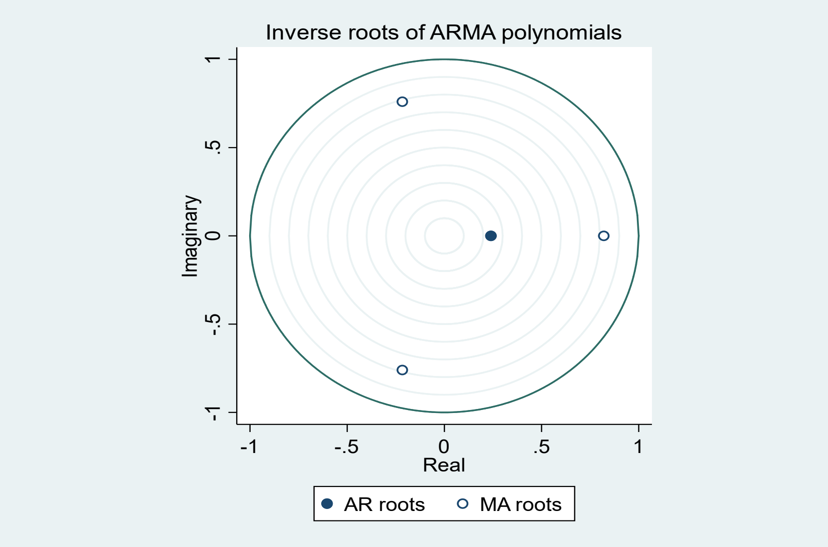

Figure 6. AR roots and MA roots

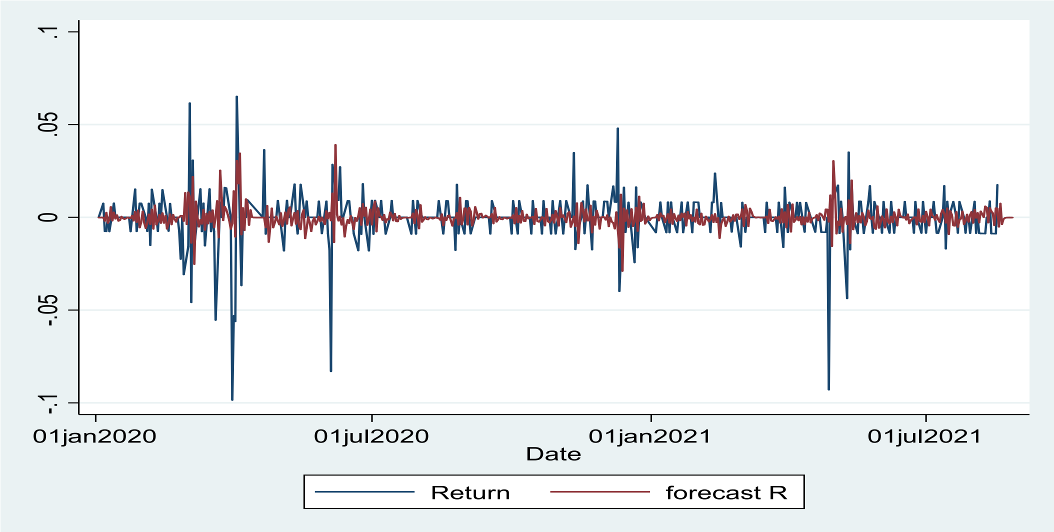

Figure 7. Forecasting of Stock Return

Table 2. Actual Value vs. Forecast Value

Date	Actual Value	Forecast Value	Differences
Aug 15, 2021	0.0000	-0.0043	0.0043
Aug 16,2021	-0.0088	0.0049	0.0137
Aug 17, 2021	0.0175	0.0047	-0.0128
Aug 18,2021	-0.0175	-0.0051	-0.0124
Aug 19,2021	0.0088	0.0074	0.0014