Risk evaluation on leading companies in property and real estate subsector at IDX: A Value-at-Risk with ARMAX-GARCHX approach and duration test

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Abstract. Risk assessment and evaluation becomes essential for financial institution to measure the potential risk of their counterparties. In middle of 2016 until first quarter of 2017, there is national program from Indonesian government so-called Tax Amnesty. One subsector that has potential to receive positive impact from the Tax Amnesty program is property and real estate. This work evaluates the risk of top five companies in term of capital share listed in Indonesia stock exchange (IDX). To do this, the Value-at-Risk (VaR) with ARMAX-GARCHX approach is employed. The ARMAX-GARCHX simultaneously models the adaptive mean and variance of stock return of each company considering exogenous variables, i.e. IDR/USD exchange rate and Jakarta Composite Index (JCI). The risk is evaluated in scheme of time moving window. The risk evaluation using 5% quantile with window size 500 transaction days perform better result compare to other scenarios. In addition, duration test is used to test the dependency between shortfalls. It informs that series of shortfall are independent.

1. Introduction
One of the macroeconomic indicators that can be used to determine the economic conditions of a country is the conditions of the capital market in that country. The capital market has two main functions in carrying out its role: (i) as a means for companies to obtain funds from investors, and (ii) as a means of investment for society. The rate of return on investment is associated with risk. There are two kind of return: (i) expected return, i.e. the return anticipated by investors in the future, and (ii) actual return, i.e. the return that has been obtained. Risk is the possibility of realization of actual return is lower than the expected minimum return. Risk and return have a positive relationship.

In the year 2016, the Indonesian government is being vigorous in carrying out the national development particularly in infrastructure which is also simultaneously deciding the rules concerning tax amnesty start from first of July. The tax amnesty was predicted have an effect on the property sector which was indicated by the increase of stock prices of companies in property sector at the closing of last transaction day before the tax amnesty start (28/06/2016) by 0.68%. Under the property sector there is property and real estate subsector. In IDX, the companies in these subsectors with highest market capitalization in 2015 include PT. Ciputra Development (CTRA), PT. Bumi Serpong
Damai (BSDE), PT. Lippo Karawaci (LPKR), PT. Summarecon Agung (SMRA), and PT. Pakuwon Jati (PWON). To invest in these five companies, it is required good risk management policies. Such risk analysis can be done through estimating stock risk level using Value-At-Risk (VaR) [1, 2]. Another subsector that possibly receives positive impact from tax amnesty program is construction and building as was analysed by Prasto, et. al [3].

The VaR method encapsulates minimum losses at a certain level of confidence [2]. The stock prices are influenced by macroeconomic factors such as IDR/USD exchange rates and JCI, as exogenous variables in addition to historical return model with non-homogeneous variance in residual. Therefore, in this research the VaR estimation is done by ARMAX-GARCHX approach. The mean part in VaR is approximated by the ARMAX model, while the variance part is approached by using GARCHX model in order to capture the volatility. This study aims to analyse the risk of return on the shares of BSDE, PWON, LPKR, SMRA, and CTRA using VaR with ARMAX-GARCHX approach. Moreover, the VaR calculation is based on the moving window concept. The existence of this research is expected to provide information in the investment policy to the investors who will invest in companies listed in IDX belong to property and real estate subsector.

2. Method

The statistical methods employed in this research are written briefly in the following subsections.

2.1. Capital Asset Pricing Model (CAPM)

Stock return ($R_t$) is the profit or loss received by stock holder computed as follows:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}},$$

where $P_t$ is closing price of stock at time $t$. The return of an individual stock as in (1) is compared with return of the market to measure sensitivity of that stock using CAPM.

The CAPM is used to describe the effect of the market on the return of an asset. In this study, the return of market is represented by the return of JCI or Indeks Harga Saham Gabungan (IHSG). Equation (2) is used to calculate the returns of a risky asset:

$$r_a = r_f + \beta_a(r_m - r_f)$$

with $r_f$ is return from risk free investment, $\beta_a$ so-called Beta is the risk measure of corresponding investment, and $r_m$ is return from the market (JCI).

2.2. ARIMAX and GARCHX Model

The combination of Autoregressive (AR) and Moving Average (MA) processes is Autoregressive Moving Average (ARMA) process [4]. ARIMAX is a development of ARIMA model by adding exogenous variable to the model. In this study, the stages of the development of procedures for the formulation of ARIMAX model consist of the method forming the model with the input metric scale. This research employs ARMAX because return value is time series that stationary in mean (around zero). The general ARMAX model is presented in (3) as follows:

$$R_t = \beta X_t + \phi_1 R_{t-1} + \cdots + \phi_p R_{t-p} + \alpha_t + \theta_1 a_{t-1} + \cdots + \theta_q a_{t-q},$$

where $X_t$ is an exogenous variable at time $t$ with its corresponding coefficient $\beta$. More general, the $X_t$ can be replaced by $X_{t-1}$ or $X_{t-p}$ depends on time lag giving reasonable interpretation or more accurate forecasting. Another form of ARIMAX model is applied by [5] that employ ARIMA model for residual of time series regression. The multivariate version of this approach (VARI-X) was proposed by [6].

The Generalized Autoregressive Conditional Heterocedasticity (GARCH) introduced by [7] is commonly employed for data with high volatility in finance. The ARCH model is built due to the influence of residuals in the past against conditional variance today. Today's conditional variance can be influenced not only by the squared residual at the past, but also can be affected by the residual's variance at past. Therefore, GARCH can handle the deficiency of ARCH model. The GARCH ($r, s$) model is formulated in (4) as follows [7]:

$$\sigma_t^2 = \phi_0 \sum_{j=1}^r \phi_j a_{t-j}^2 + \sum_{j=1}^s \lambda_j \sigma_{t-j}^2,$$
with $\lambda_j \geq 0, j=1,2,...,s$. The GARCH with Exogenous Variables (GARCHX) is formulated in (5) following [8, 9]. The GARCH$(r, s)$-X$(0_1, 0_2, ..., 0_m)$ has following form:

$$\sigma_t^2 = \varphi_0 + \sum_{j=1}^r \varphi_j a_{t-j}^2 + \sum_{j=1}^s \lambda_j \sigma_{t-j}^2 + \sum_{l=1}^m \gamma_l x_{lt}^2,$$  \hspace{1cm} (5)

where $\gamma_l \geq 0$. The part $X(0_1, 0_2, ..., 0_m)$ can be replaced by $X(p_1, p_2, ..., p_m)$ if the significant lag is $p_1$ for $X_1$, lag $p_2$ for $X_2$, and $p_m$ for $X_m$.

2.3. Value at Risk and Backtesting

The calculation of the VaR value at time $t$ using normal distribution approach is formulated in (6) as follows:

$$\text{VaR}_\tau(t) = \hat{\mu}_t + F^{-1}(\tau) \hat{\sigma}_t,$$  \hspace{1cm} (6)

where $F^{-1}(\tau)$ is the inverse cumulative distribution function of standard normal distribution for quantile $\tau$. In this study, VaR model is calculated by estimating $\hat{\mu}_t$ using ARMAX model, while $\hat{\sigma}_t$ is estimated using GARCHX model.

Backtesting is one method that can be used to perform the validity or accuracy of a VaR model built over the realization of the market. The risk function for backtesting is shown in the (7):

$$I_{\tau,t} = \begin{cases} 1, & r_t < -\text{VaR}_{\tau,t} \\ 0, & r_t \geq -\text{VaR}_{\tau,t} \end{cases}$$  \hspace{1cm} (7)

The average of indicator function $I_{\tau,t}$ is compared with the risk preference with probability $\tau$.

3. Data and Variable

The stock price data was downloaded from finance.yahoo.com for BSDE, PWON, LPKR, SMRA, CTRA, and IHSG. The JCI series was also sourced from the same website. The USD/USD exchange rate data was obtained from the bi.go.id website. The period of the data spans from January 1, 2010 until September 30, 2016.

![Figure 1. Time series plot of stock close price.](image)

In figure 1, it is known that the stock price movement of the five companies has the same pattern. PWON's stock price is lower than that of other companies. It also showed that the highest stock price increase occurred in early 2013. However, in mid-2013 and 2015 there was a decline in stock prices. This is due to the policies of Bank Indonesia (BI), as a central bank of Indonesia, about loan to value (LTV) II in September 2013 and LTV III in June 2015 for property sector loans. In addition, there was an increase of interest rates in June 2013 by 7.5%. This BI policy resulted in a decline in demand for
housing on credit which affected the decline in property stock prices. The descriptive statistic of returns of these five firms is summarized in table 1.

| Firm | Mean | Variance | Coef. of Var. | Min | Max | Skewness | Kurtosis |
|------|------|----------|---------------|-----|-----|----------|----------|
| BSDE | 0.0010 | 0.00079 | -0.218 | 0.161 | 0.01 | 5.09 |
| PWON | 0.0014 | 0.00072 | 1947.2 | -0.125 | 0.172 | 0.27 | 2.91 |
| LPKR | 0.0008 | 0.00061 | 3302.9 | -0.177 | 0.135 | -0.06 | 4.33 |
| SMRA | 0.0012 | 0.00097 | 2558.7 | -0.478 | 0.127 | -2.15 | 35.68 |
| CTRA | 0.0014 | 0.00117 | 2521.6 | -0.518 | 0.240 | -1.66 | 35.11 |

The PWON and CTRA have higher average stock returns. When it is viewed from the smallest coefficient of variance, it appears that the PWON has a more stable stock return. One company with the highest and lowest share return value is CTRA. This means that the maximum loss and profitability of CTRA is higher than other companies. Based on the value of skewness and kurtosis, it is known that the stock return data of the five companies do not follow the normal distribution because the value of skewness is not equal to zero and kurtosis value is not equal to 3.

The characteristics of daily stock price of the five companies can be seen in table 2. There are same characteristics on Monday which (in average) have negative returns. This means the returns tend to lose on Monday. On that day, stock return fluctuate highly indicated by their variances are high enough compared to other days. This phenomenon is called Monday effect. Moreover, when it is viewed from the monthly stock return, PWON and LPKR have the same median per month at about zero. The month with highest median return for BSDE and SMRA is in October at 0.00339 and 0.00602, respectively, while for CTRA is in January about at 0.00349. Hence, at that month the stocks tend to give profit.

Characteristics for exogenous variables of IDR/USD and JCI can be seen in figure 2. The pattern of movement of the IDR/USD exchange rate from day to day tends to increase, but it decreased in mid-2011 which reached the lowest value of Rp8,502.00. But since then, the IDR/USD exchange rate has always increased. The drastic increase occurred in mid-2013 to Rp12,331.00 and the highest IDR/SD rate occurred in mid-2015 reaching Rp14,802.00. This phenomenon also coincided with the increase in BI rate to 7.5% which also affected the weakening of JCI at that time, as shown in figure 2(b). It appears that when the IDR weakened in mid-2013 and 2015, the rate of JCI precisely decreases. The decline of JCI is affecting the declining value of shares from several sectors such as property sector. Therefore, the movement of the IDR/USD exchange rate and JCI is able to influence the increase and decrease the stock price of a company.
4. Empirical Results

The CAPM aims to prove the theory about the influence of JCI as market price against the fifth stock of the company. The window used is 250 day transaction to estimate beta parameters of CAP as in figure 3. In the CAPM analysis, the variable used as risk free rate is the BI interest rate. In figure 3, it is known that CTRA has beta coefficient is greater than one in each window, which means that the sensitivity level of the stock is higher than the JCI. The BSDE, PWON, LPKR, and SMRA have beta coefficient values between zero and two in each window. This means that at the condition 0 < β < 1, the stock sensitivity level is lower than JCI and at the condition β > 1 the sensitivity level of the stock is higher than JCI. The significance test of beta coefficient is summarized in table 3.

![Time series plot of (a) IDR/USD exchange rate and (b) JCI.](image)

**Figure 2.** Time series plot of (a) IDR/USD exchange rate and (b) JCI.

![Beta coefficient of CAPM for (a) BSDE, (b) PWON, (c) LPKR, (d) SMRA, and (e) CTRA.](image)

**Figure 3.** Beta coefficient of CAPM for (a) BSDE, (b) PWON, (c) LPKR, (d) SMRA, and (e) CTRA.
### Table 3. Significance Test for Beta coefficient in CPAM.

| Firm | Window | β   | P-value | Decision |
|------|--------|-----|---------|----------|
| BSDE |        | 1.5139731 | 1.57E-31 | Significant |
| PWON |        | 1.5112445 | 1.30E-21 | Significant |
| LPKR | 1      | 0.9413177 | 8.34E-12 | Significant |
| SMRA |        | 1.8372709 | 1.02E-15 | Significant |
| CTRA |        | 1.4159665 | 1.50E-15 | Significant |

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\[ \text{Table 4. Parameter estimation of GARCHX model for return of BSDE.} \]

| Model           | Param. | Estimate | t-value | p-value |
|-----------------|--------|----------|---------|---------|
| GARCH(0,1) - X(-,0) | ω  | 0.000002 | 957.49 | ≈ 0 |
|                 | λ₁    | 0.996586 | 6699.19 | ≈ 0 |
|                 | γₐ    | 0.000169 | 4.19 | 2.80E-05 |

\[ \sigma_t^2 = 0.000002 + 0.996586 \delta_{t-1}^2 + 0.000169 X_{2,t}^2 \]  

4.1. ARMAX-GARCHX Modelling

As known from Table 3, at α=5% the p-value of β for the five companies in each window has a value less than α such that it can be concluded that the JCI return significantly influence the return of each company. Thus, the results of this CAPM analysis support the theory that JCI affects individual stocks.

**Table 4. Parameter estimation of GARCHX model for return of BSDE.**

| Model           | Param. | Estimate | t-value | p-value |
|-----------------|--------|----------|---------|---------|
| GARCH(0,1) - X(-,0) | ω  | 0.000002 | 957.49 | ≈ 0 |
|                 | λ₁    | 0.995397 | 39434.01 | ≈ 0 |
|                 | γₐ    | 0.00458 | 414.13 | ≈ 0 |

\[ \sigma_t^2 = 0.000002 + 0.995397 \delta_{t-1}^2 + 0.00458 X_{2,t}^2 \]

Based on Table 5, each parameter has |t-value| > |t-table| amounted to 1.96, such that the model for BSDE is GARCH(0,1)-X(-,0) with significant exogenous variable is IDR/USD exchange rate. The model is formulated as follows:

\[ \sigma_t^2 = 0.000002 + 0.995397 \delta_{t-1}^2 + 0.00458 X_{2,t}^2 \]  

**Table 5. Parameter estimation of GARCHX model for return of PWON.**

| Model           | Param. | Estimate | t-value | p-value |
|-----------------|--------|----------|---------|---------|
| GARCH(0,1) - X(-,0) | ω  | 0.000002 | 9.87 | ≈ 0 |
|                 | λ₁    | 0.995397 | 39434.01 | ≈ 0 |
|                 | γₐ    | 0.00458 | 414.13 | ≈ 0 |

Based on Table 5, each parameter has |t-value| > |t-table| = 1.96 which means the model parameters are significant. The model that is suitable for PWON is GARCH(1,0)-X(-,0) with significant exogenous variable is IDR/USD exchange rate as formulated:

\[ \sigma_t^2 = 0.000002 + 0.995397 \delta_{t-1}^2 + 0.00458 X_{2,t}^2 \]
Table 6. Parameter estimation of ARMAX-GARCHX model for return of LPKR.

| Model                   | Param. | Estimate  | t-value | p-value |
|------------------------|--------|-----------|---------|---------|
|                         | $\phi_1$ | 0.095401  | 3.70    | 0.000213|
| ARMA(1,0)-X(0,0)       | $\beta_1$ | 1.016844  | 21.58   | $\approx$ 0 |
| &                      | $\beta_2$ | -0.36511  | -3.31   | 0.000945|
| GARCH(1,1)-X(0, -)     | $\varphi_1$ | 0.019499  | 308.19  | $\approx$ 0 |
|                        | $\lambda_1$ | 0.976336  | 788.97  | $\approx$ 0 |
|                        | $\gamma_1$ | 0.000553  | 2.05    | 0.040666|

Table 6 list the parameters estimates of model for LPKR. The model is ARMA(1,0)-X(0,0) and GARCH(1,1)-X(1, -), where significant exogenous variable in ARMAX model are JCI and IDR/USD exchange rate while in the one in GARCHX model is JCI. The LPKR stock return model is as follows.

$$\hat{R}_t = 0.095401 R_{t-1} + 1.01684 X_{1,t} - 0.3651 X_{2,t}$$

$$\hat{\sigma}_t^2 = 0.000002 + 0.01949 \hat{\sigma}_{t-1} + 0.976336 \hat{\sigma}_{t-1}^2 + 0.000553 X_{1,t}^2$$

(10)

Table 7. Parameter estimation of GARCH model for return of SMRA.

| Model                   | Param. | Estimate  | t-value | p-value |
|------------------------|--------|-----------|---------|---------|
| GARCH(0,1)-X(- ,0)     | $\omega$ | 0.000009  | 756.3   | $\approx$ 0 |
|                        | $\lambda_1$ | 0.988899  | 2874.4  | $\approx$ 0 |
|                        | $\gamma_1$ | 0.007913  | 128.5   | $\approx$ 0 |

In table 7, the SMRA stock return model is GARCH(0,1)-X(- ,0) where the IDR/USD exchange rate as its exogenous variable:

$$\hat{\sigma}_t^2 = 0.000009 + 0.988899 \hat{\sigma}_{t-1}^2 + 0.007913 X_{2,t}^2$$

(11)

In CTRA stock return modelling, the result of GARCHX model parameter estimation using window length 250 transaction days, the 3 experiments is expected to represent the modelling in other window. The CTRA return model is listed in table 8.

Table 8. Parameter estimation of GARCHX model for return of CTRA in three windows.

| Interval     | Model                   | Par. | Estimate  | t-value | p-value |
|--------------|-------------------------|------|-----------|---------|---------|
| 1 until 250  | GARCH(0,1)-X(- ,0)      | $\omega$ | 0.000011  | 12.60   | $\approx$ 0 |
|              |                         | $\lambda_1$ | 1  | 6693.56  | $\approx$ 0 |
|              |                         | $\gamma_1$ | 0.077516 | 1273.85 | $\approx$ 0 |
| 2 until 251  | GARCH(0,1)-X(- ,0)      | $\omega$ | 0.000009  | 39.99   | $\approx$ 0 |
|              |                         | $\lambda_1$ | 1  | 2525.63  | $\approx$ 0 |
|              |                         | $\gamma_1$ | 0.067849 | 439.39  | $\approx$ 0 |
| 3 until 252  | GARCH(0,1)-X(- ,0)      | $\omega$ | 0.000009  | 57.01   | $\approx$ 0 |
|              |                         | $\lambda_1$ | 1  | 2661.24  | $\approx$ 0 |
|              |                         | $\gamma_1$ | 0.092593 | 706.70  | $\approx$ 0 |
After re-modelling the window by 3 times it was obtained the model with the parameters that is always significant in the 3 experiments is GARCH(0,1)-X(-.0) where the exogenous variable is the IDR/USD exchange rate:

Window 1 : \[ \hat{\sigma}_t^2 = 0.000011 + 1 \hat{\sigma}_{t-1}^2 + 0.0775 X_{2,t}^2 \]
Window 2 : \[ \hat{\sigma}_t^2 = 0.000009 + 1 \hat{\sigma}_{t-1}^2 + 0.0678 X_{2,t}^2 \]
Window 3 : \[ \hat{\sigma}_t^2 = 0.000009 + 1 \hat{\sigma}_{t-1}^2 + 0.0926 X_{2,t}^2 \]

### 4.2. VaR Estimation

The risk estimation of the five companies is done using ARMAX-GARCHX approach, where the mean part in VaR model is approached with ARMAX model while the variance part is approximated by GARCHX model. The VaR calculations are performed on each window with interval length 250, 375, and 500 days transactions and 5% quantile are used.

Based on table 9, it is found that at the 95% confidence level the biggest maximum loss value experienced by an investor when investing IDR 1 Billion in each company: IDR 43,580,000.00 (BSDE), IDR 46,480,000.00 (PWON), IDR 32,410,000.00 (LPKR), IDR 52,100,000.00 (SMRA), and IDR 51,600,000.00 (CTRA). It is also known that companies that provide the highest and lowest loss rates in window size 250 are CTRA and LPKR, while companies that provide the highest and lowest loss rates on windows size 375 and 500 are SMRA and LPKR, respectively. This VaR estimate applies when the economy is in a normal or non-crisis state. The accuracy of the VaR (quantile 5%) estimation of each window using back testing method is reported in table 10.

### Table 9. Estimation of Risk (Loss) and Profit using VaR.

| Firm   | Statistic | Loss Window length | Profit Window length |
|--------|-----------|--------------------|---------------------|
|        |           | 250 | 375 | 500 | 250 | 375 | 500 |
| BSDE   | Mean      | -   | -   | -   | 0.0433 | 0.0432 | 0.0436 |
|        | Variance  | 0.0002 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 |
| PWON   | Mean      | -   | -   | -   | 0.0430 | 0.0447 | 0.0465 |
|        | Variance  | 0.0002 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 |
| LPKR   | Mean      | 0.0324 | 0.0318 | 0.0320 | -   | -   | -   |
|        | Variance  | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| SMRA   | Mean      | 0.0488 | 0.0508 | 0.0521 | 0.0488 | 0.0508 | 0.0521 |
|        | Variance  | 0.0003 | 0.0002 | 0.0001 | 0.0003 | 0.0002 | 0.0001 |
| CTRA   | Mean      | 0.0505 | 0.0507 | 0.0516 | 0.0505 | 0.0507 | 0.0516 |
|        | Variance  | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0002 | 0.0001 |

### Table 10. Back testing of VaR.

| Firm Window | Risk | Profit | Difference (%) |
|-------------|------|--------|----------------|
|             | Loss | Expected Shortfall (%) | Loss | Expected Shortfall (%) | Risk | Profit |
| BSDE        | 250  | 63 | 4.62 | 79 | 5.80 | 0.38 | 0.80 |
|             | 375  | 61 | 4.92 | 71 | 5.73 | 0.08 | 0.73 |
|             | 500  | 49 | 4.40 | 53 | 4.76 | 0.60 | 0.24 |
It is known that the results of risk and profit estimation are almost the same; this is due to symmetry VaR condition. The comparison of VaR estimates for BSDE, PWON, SMRA, and CTRA did not differ significantly. Risk and profit estimates in LPKR have a considerable difference from the 5% quantile, indicating that the VaR estimate in this firm tends to be under-estimate. Unlike the case of BSDE, PWON, SMRA, and CTRA which the difference is not too far away from the 5% reference value, which means that the VaR estimates of other companies provides fairly accurate results. It is also known that the calculation of risk and profit by using the window size 500 tends to produce a smaller loss and expected shortfall than using windows size 250 and 375. Hence, the VaR calculation by using observation within windows size 500 transaction days gives a more accurate VaR estimate.

In addition, the duration test is employed to test the dependency of shortfall series. The empirical test shows that there is no dependency between shortfalls. For further research, it is recommended to employ other nonlinear GARCH methods for VaR calculation. Conditional VaR (CVaR) method can be used in subsequent research to accommodate stock dependencies between companies. While other back testing methods are also suggested such as Kupic test, Quantile regression, and duration based model. Similar risk analysis as done by [10] about default prediction will be useful for financial analysis.

5. Conclusion
Companies with the highest and lowest share price averages are SMRA and PWON. The highest and lowest return value is owned by CTRA, which means that the maximum loss and profitability of the CTRA is higher than the others. The five stock returns tend to be negative on Monday which indicates Monday effect phenomenon. The BSDE and SMRA tend to experience profits in October, CTRA in January, while PWON and LPKR are stable every month. The movement pattern of the IDR/USD exchange rate and JCI is always increasing every year. In the CAPM analysis, it is proven that the JCI has a significant effect on the five stocks. It is also note that companies providing highest and lowest loss when estimated using window size 250 transaction days are CTRA and LPKR, while the highest and lowest loss estimated on window size 375 and 500 are SMRA and LPKR, respectively. The estimates of VaR score of LPKR tend to be under-estimate. Moreover, the VaR estimation using 500 transaction days in each window gives more accurate estimates of VaR. Moreover, the VaR estimate using the GARCHX approach yields a more accurate prediction than using the ARMAX-GARCHX. This is because the ARMAX model is redundant. Further research is suggested to use the GARCHX method by assuming the mean model is zero.

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