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COMPARISON BETWEEN VALUE AT RISK AND ADJUSTED EXPECTED SHORTFALL: A NUMERICAL ANALYSIS

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ABSTRACT

Loss risk is one of the variables that always appears in every kind of investment. On stock asset investments, the characteristics of the risk of loss are uncertain, and this means that losses can occur at any time with a value that cannot be determined. From this condition, investors must manage the loss risk appropriately in order to retain investment stability and get optimal profits. One of the important processes in risk management is loss risk forecast. Risk forecast can be done using risk measures. In stock investment, Value at Risk (VaR) is the most widely used risk measure because has a simple model and can be applied to many types of stocks. However, VaR does not satisfy the axiom of subadditivity. Thus, VaR is not a coherent risk measure. Another risk measure that is coherent and can be used as an alternative to predict loss risk is the Adjusted-Expected Shortfall (Adj-ES). This study aims to compare VaR and Adj-ES through numerical analysis and backtesting tests. Therefore, we can get references to conclude the best risk measure for predicting losses on stock investments. The data used in this study are 2022 IDX blue chip, i.e., EXCL.JK and ICBP.JK from 09/01/21 to 09/09/22. Based on the backtesting test, the violation ratio value for Adj-ES in every violation probability is less than 1 is less than 1. Then, for VaR at 1% violation probability, the violation ratio value is > 1.

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1. INTRODUCTION

Economic activity in a country is one of the essential activities that can determine economic growth. For their community, economic activities are the main means to improve their welfare and standard of living. According to [1], the main motivation of each individual when carrying out economic activities is to obtain maximum profit with minimum risk. Based on the press release from Indonesian Coordinating Minister for the Economy, five sectors support the Indonesian economy: manufacturing, trade, construction, and mining [2]. Every year, these five sectors contribute the largest to the value of Indonesia Gross Domestic Product (GDP) value. In the 2010-2020 interval, the average total contribution of these sectors to the GDP of Indonesia is more than 50% per year [3]. Along with technological advances and the development of science, the economic activities of the Indonesian people no longer only focus on these sectors. People began to use the capital they had for use in other sectors.

According to [4] one sector that attracts public interest is financial assets investment in the capital market. The main attraction offered by this kind of investment is that it can give big profit in a short time. In addition, several advantages that encourage people to invest in financial assets include the fact that they generally have high liquidity, so that they can be a guarantee for investors that it will be quite easy to find buyers if they are going to sell their assets [5]. Then, the maintenance costs of financial assets are small and not as expensive as the maintenance costs of real assets. The process of buying and selling real assets is simpler and more flexible. The last, the return value can be measured and predicted accurately using the right mathematical model. The process of financial asset transactions between investors occurs in the capital market. In Indonesia, the authorized capital market which is the center for trading financial assets is the Indonesia Stock Exchange [6]. Since it opened in 2007, there have been at least seven products of financial assets traded: stocks, bonds, mutual funds, Exchange Traded Funds (ETFs), Structured Warrants, Real Estate Investment Funds, and Derivative assets. Based on [2] and [3], investors significantly increased in 2017-2022. In 2017 the number of investors registered in IDX Indonesia was 1,025,414. Then, in 2022 there will be an increase of 740.73% to 8,620,911 investors.

Among all financial products at IDX Indonesia, stocks have become the most preferred by investors [7]. In 2022, 4,023,442 of 8,620,911 investors listed on IDX Indonesia were stocks investor. According to [8], besides the motivation to obtain maximum profit, the consideration of investors in choosing stocks as their investment assets is by referring to the company's performance. Every year, IDX Indonesia releases a list of stocks that are included in the Blue-Chip category. This release aims to provide information regarding stocks with a good national reputation in terms of quality, ability, and reliability to operate profitably in good and bad economic situations. Stocks in the Blue-Chip category also tend to have stable movements throughout the year, making them appropriate and safer for investment assets [9]. The existence of information about Blue Chip stock is very helpful for investors.

However, every stock investment cannot be separated from the loss risk factor. This risk is unavoidable and can occur at any time. Hence, investors require the right risk management strategy to keep their investment activity stable and avoid bankruptcy [10], [11] and [12] stated that, in order to determine the right risk management strategy, investors must accurately know the estimated value of the risk of loss in the future. The risk measure is one of the mathematical models that can be used to accurately predict the loss value [13]. Then, Value at Risk (VaR) and Expected Shortfall (ES) are the most frequently used risk measures for predicting losses on stock assets. VaR defined as the maximum prediction of loss risk that will occur at a certain period with $(1-\alpha)$ % confidence interval and t-day holding period. Furthermore, ES is a prediction of the average loss risk when the loss risk exceeds VaR. Either VaR or ES are predicted loss risk based on historical stock returns. [14] state that these two risk measures have drawbacks. For VaR, it does not meet the subadditive axiom so it is not a coherent risk measure. Then, the ES value is easily affected by outlier data, that condition implies the predictions become inaccurate when there are outliers in stock return data.

Therefore, in this research, we will use the Adjusted-Expected Shortfall (Adj-ES) as an alternative model for predicting the risk of loss. Adjusted Expected Shortfall is a coherent risk measure proposed by [15] which can correct the weaknesses found in VaR and ES. This study aims to predict the loss risk on IDX Indonesia 2021 Blue Chip stock using VaR and Adj-ES models and select the best model by backtesting accuracy test. The best model is expected to be a relevant reference for investors to formulate correct risk management strategies. Previous studies that examine loss risk predictions on IDX Indonesia Blue Chip stocks include valuating several Blue-Chip stocks using VaR model with Monte Carlo Simulation approach [7]. At the 99% confidence level, the possible losses for Blue Chip were in the range of 4.66%-5.96%. [16]

estimates the risk of loss in Indonesian Blue-Chip stocks, especially the banking sector using the VaR-Historical Simulation model. According to the result, Bank Mandiri has the highest investment risk and BCA has the lowest investment risk. [17] made Value at Risk (VaR) analysis on Indonesian Blue Chip Stock investment with Copula approach. The result show that Copula Gumbel model was the best model because of could get more better heavy tail data based on VaR value.

The data for this research are taken from the Historical Price of 2022 Blue Chip stocks, including XL Axiata Company (EXCL.JK) and Indofood CBP Sukses Makmur Company (ICBK.JK). These companies operate in the telecommunication and food sector that can continue to record profits during the COVID-19 pandemic from 2020-2021. So, we are interested in analyzing the prediction of the risk of loss in 2022. The novelty in this study is the numerical comparison of VaR and Adj-ES and then measuring its accuracy using the Backtesting accuracy test.

2. RESEARCH METHODS

In this section will be explained the theories and models that are used for data analysis. The study will begin with the concept of return on stock assets, then continue with the definition of risk measures, particularly Value at Risk and Adjusted-Expected Shortfall. And lastly, is an explanation of the Backtesting test and the testing procedure procedures.

2.1 Stock Return

Return on stock asset investment is an important variable influencing investors to invest their funds. According to [18] return is defined as the relative change in the price of a financial asset over a certain time interval, which is often expressed as a percentage. [19] stated that the return of a stock price is the profit gained from investment processes in a definite time period Return is an important factor that motivates investors to invest because returns can provide a real illustration of price changes. Risk and return have a strong relationship [1]. Generally, the higher the risk associated with an investment, the higher the return will be received. Low-risk investments, such as real asset investment, offer relatively low returns as a reflection of greater security. This is known as the "risk/return trade-off". The more unstable the return obtained from an investment, the higher the risk faced. When two investments have the same return, the decision on which investment to take is based on the lower risk.

Returns can be realized returns (already happened) or expected returns (has not happened yet but is expected to occur in the future). Realized return is calculated based on historical data. Return realization is important because it is used as a measure of company performance. The realized return is also useful for determining the expected return and predicting future risk. The expected return is the return that is expected to be obtained by investors in the future. In contrast to the realized return, which has already occurred, the expected return has not yet occurred [20]. The following equation gives the formula for log return [20]:

$$\mathrm{R_t} = ln\left(\frac{P_t}{P_{t-1}}\right) = ln(P_t) - ln(P_{t-1}) \tag{1}$$

where Rt is the return at period t, P_t and P_{t-1} is the stock price in period t, and ($t-1$). The advantage of using log returns is that log returns are more consistent and economically meaningful than simple net returns. This advantage makes the return log more widely used for calculating realized and expected returns.

2.2 Risk Measure

Risk measurement is a quantitative method used to forecast the value of losses on investment for a certain period. Referring to [21], risk measure is effective if it fulfills the four axioms of risk measurement. The axioms should apply to any risk measure that will be used to manage risk effectively. The four axioms must be fulfilled: Translation Invariance, Positive Homogeneity, Monotonicity, and Subaditivity.

1. Value at Risk (VaR)

VaR is a type of risk measure that calculates the number of losses that can occur by knowing the assets position, the level of confidence in the risk occurrence, and the holding period of asset placement [22]. In other words, VaR will answer the question "how much (in percent or a certain amount of money) investors can lose in the *t*-th investment time with a confidence level of (1-α)". The VaR value is always accompanied by a probability that shows how likely the loss will be less than the VaR value.

Suppose X is a random variable that expresses the return on a stock, for $\alpha \in (0,1)$, according to [23], *VaR* at the confidence level (1-α) is the quantile (α) of the *X* distribution, so:

$$P(X \leq q_\alpha) = \alpha \tag{2}$$

$$F_X(q_\alpha) = \alpha \tag{3}$$

Since $q_\alpha = VaR_{1-\alpha}(X)$, we get:

$$VaR_{1-\alpha}(X) = F_X^{-1}(\alpha) \tag{4}$$

Where $F_X^{-1}(\cdot)$ is the inverse of $F_X(\cdot)$ as a distribution function of the random variable *X*. In a more general equation, VaR can also be expressed as follows:

$$VaR_\alpha(X) = sup\{x \in R | F_X(x) \leq (\alpha)\} \tag{5}$$

The following figure is an illustration of VaR on the probability density function and distribution function curve for stock returns that follow the Normal distribution:

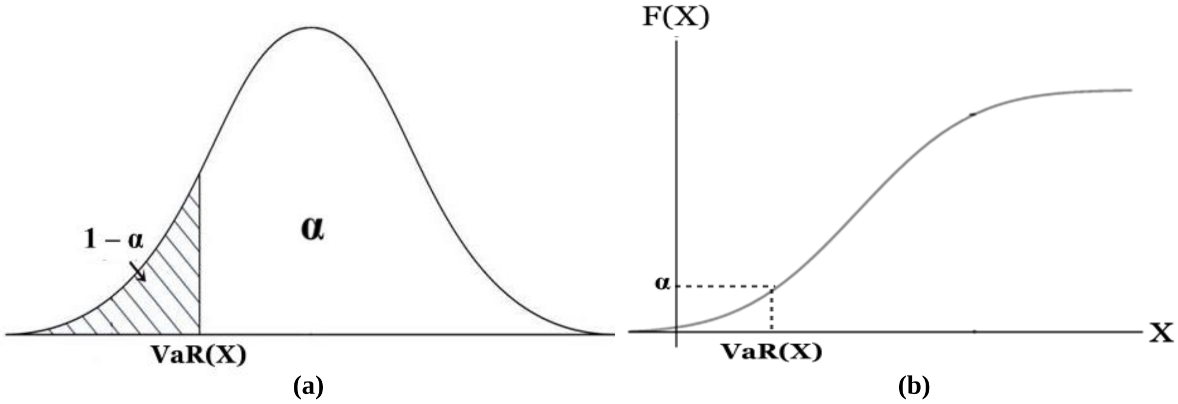


Figure 1. Illustration of VaR on curve (a) probability function; (b) distribution function for normally distributed returns

Based on **Figure 1**, it can be concluded that the greater the level of confidence (α), the greater the VaR value and the smaller the possibility of loss that exceeds VaR.

Historical Simulation Approach for VaR Prediction

There are three approaches to the VaR model for estimating the possible loss of investment. The first is the VaR model with a parametric approach which assumes that the distribution of returns follows the Normal distribution. Often on stock investments, the return data obtained do not follow the normal distribution but tend to have a thick tail distribution (leptokurtic). This condition causes the parametric method not easy to apply to any stock data [24]. Therefore, a nonparametric approach was introduced to overcome this problem. One of the most widely used nonparametric methods is Historical Simulation (HS). The third is the semiparametric method, which combines the previous methods to predict VaR.

HS is a simple method for estimating risk and relies on the assumption that history repeats itself, i.e., one of the observed past losses can be repeated as the value of the loss in the next period [25]. While [4] clearly states that the main concept of this methodology is to predict future losses based on past losses. In stock investment, the HS method predicts the value of losses using historical return data without requiring historical returns to be normally distributed.

HS is seen as the simplest method for VaR prediction because it is relatively easy to implement, and no distribution assumptions must be met. At the level of confidence (1-α), VaR is obtained using the following equation:

$$VaR^{HS}_{1-\alpha,T}(X) = V_0 \delta \sqrt{T} \tag{6}$$

where *X* is stock return, (1-α) is confidence level, *T* denotes holding period, V_0 is an investment fund, and δ is α-the quantile for ordered stock return data.

2. Adjusted Expected Shortfall (Adj-ES)

Value at Risk and Expected Shortfall are risk measures most often used to measure risk in financial assets. However, each of these risk measures has drawbacks; the VaR model does not meet the axiom of subadditivity, so VaR is not a coherent measure of risk. Then, the drawback of ES is that this model provides biased risk prediction results if there are outlier values in the data. [26] suggest Adjusted Expected Shortfall (Adj-ES) as an improvement from the VaR and ES models. The definition of Adj-ES is:

Definition 1. For a random variable X, $\alpha \epsilon (0,1)$, and $c \epsilon [0,0.1]$, Adj-ES at the α confidence level, denoted Adj-$ES_{\alpha,c}(X)$ is the average loss value that is at the interval $VaR_\alpha(X)$ and $VaR_{\alpha+(1-\alpha)^{1+c}}(X)$, so the equation is as follows [26]:

$$\text{Adj-ES}_{\alpha,c}(X) = -E\left[X \middle| -VaR_{\alpha+(1-\alpha^c)}(X) \geq -X \geq -VaR_\alpha(X)\right], \tag{7}$$

with the confidence level is $100(1-\alpha^{1+c})\%$

If we suppose $VaR_\alpha(X) = a$ and $VaR_{\alpha+(1-\alpha^c)}(X) = b$, then by utilizing **Equation (6)**, we will obtain the equation of the Adj-ES model as follows:

$$\begin{aligned}\text{Adj-ES}_{\alpha,c}(X) &= -\frac{1}{P(-b\geq -X \geq -a)}\int_b^a x\, f(x)\, dx \\ &= -\frac{1}{(\alpha)^{1+c}}\int_b^a x\, f(x)\, dx\end{aligned} \tag{8}$$

By substituting $F_X(x) = \mu$, $x = F_X^{-1}(\mu)$, and $dx = d\mu$, then the final equation for the model Ad- $ES_{\alpha,c}(X)$ is:

$$\text{Adj- ES}_{\alpha,c}(X) = -\frac{1}{\alpha^{1+c}}\int_{\alpha(1-\alpha^c)}^{\alpha} F_X^{-1}(\mu)\, d\mu \tag{9}$$

Adj-ES Model Estimation with Historical Simulation Approach

Let X be a random variable representing the stock price index return, with its realized value from period 1 to t being $x_1, x_2, \ldots, x_t$. Then $x_{(k)1}, x_{(k)2}, \ldots, x_{(k)t},$ as returns in ascending order. The formula for the Adj-ES model with a historical simulation approach for the random variable X is defined:

$$\text{Adj} - \text{ES}_{\alpha,c}(X) = -\frac{1}{[u]+2}\sum_{i=0}^{[u]+1} X_{(k)i} \tag{10}$$

with,

u = $n\,\alpha^{1+c}$

$[u]$: the largest integer whose value is $\leq u$

$(k)i$ = $[(n+1)\alpha'_{(i)}]$

$\alpha'_{(i)}$ = $\alpha - \frac{i\,\alpha}{[n\alpha]+1}$

i = $0, 1, 2, \ldots, ([n\,\alpha^{1+c}] + 1)$

c : real number between 0 and 0.1

2.3 Backtesting Test

The backtesting test is a statistical procedure that compares the actual return value with the predicted VaR value. For example, if the confidence level used to calculate VaR with a holding period of 1 day is 99%, it is expected that a loss exceeding the VaR will occur on average once every 100 days. In the backtesting test, it is possible to test statistically whether the frequency of occurrence of losses whose value exceeds VaR at certain time intervals corresponds to the chosen confidence level. This type of test is known as an unconditional coverage test [27].

According to [22], to perform the backtesting test, a sample of size N will be divided into two groups, namely the estimation window (K_E) and the test window (K_U). Estimation window (K_E) is a group of observations used to calculate Value at Risk. Meanwhile, the test window (K_U) is a sample from the period (K_{E+1}) to period K.

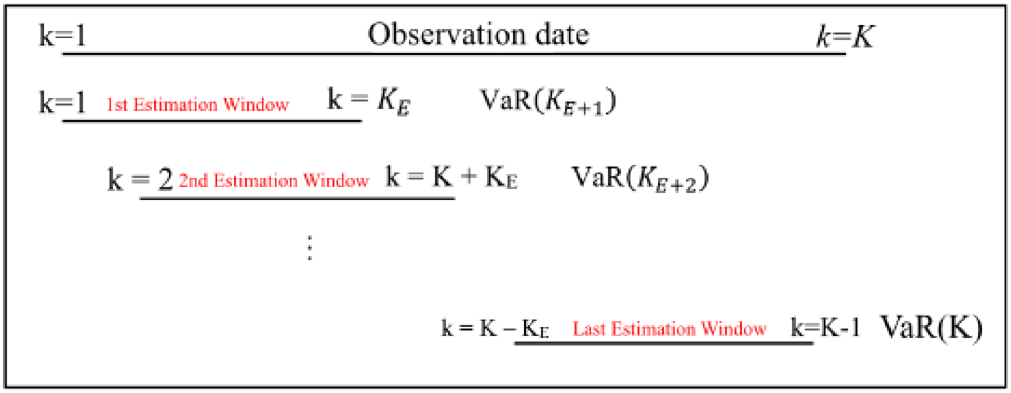


Figure 2. Illustration for estimate and test window

A violation is said to have occurred if the actual return in a certain period is lower than the VaR value in the same period. So that in measuring the quality of VaR predictions, it can be done by comparing the number of violations that occur with the expected number of violations or more often referred to as the violation ratio (Violation Ratio) [28]. In the period (N_{E+1}) to period N (test window), the violation is symbolized by η_k $k = N_{E+1}, \ldots, N$, which is worth one if there is a violation and zero if there is no violation.

$$\eta_k = \begin{cases} 1; \ if \ X_k \leq -VaR_k \\ 0; \ if \ X_k > -VaR_k \end{cases} \tag{10}$$

where X_k is the return in period k and VaR_k is loss prediction in period k.

The number of violations is symbolized by v_j with $j = \{0,1\}$, where v_1 is the number of η_k which is worth 1 (the number of days the violation occurred) and v_0 is the number that is worth 0 (the number of days without a violation) [29].

$$v_1 = \sum_{k=N_{E+1}}^{N} \eta_k \tag{11}$$

$$v_0 = N_U - v_1 \tag{12}$$

where N_U is the length of the test window. The Violation Ratio (VR) is calculated by comparing the number of violations (v_1) with the expected number of violations. Where m_0 is the probability of the alleged violation, then

$$VR = \frac{v_1}{m_0 \times N_U} \tag{13}$$

If the value of $VR = 1$, then the number of violations that occur is the same as the expected number of violations (the VaR prediction method gives the correct risk estimation result). If VR > 1 indicates that the violation occurred is greater than the expected number of violations. Meanwhile, VR < 1 indicates fewer violations than the expected number of violations [30].

2.4 Analysis Steps

The procedure for modeling the JKSE value through the stochastic model and predicting the risk of loss with Adj-ES risk measure is as follows:

1. Collected EXCL.JK and ICBP.JK historical prices in a predetermined time period
2. Divide the data into 2 groups, namely estimation window and test window
3. Measuring EXCL.JK and ICBP.JK return value on in-sample data
4. Perform normality test on in-sample returns
5. Predict the risk of loss through the VaR method. If the returns are normally distributed, the VaR measurement uses a parametric approach; else we will use a non parametric (historical simulation) approach.
6. Measuring the risk of loss using the Adj-ES method
7. Testing prediction accuracy using backtesting test

8. Choose the best model based on the result of the backtesting test

3. RESULTS AND DISCUSSION

In this study, we used daily closing price (IDR) of EXCL.JK and ICBP.JK from 09/01/21 to 09/10/22 as data sample, with the number of samples for each stock, is 252. The analysis started with descriptive and time series plots analysis. These analysis aims to obtain more detailed characteristics of stock prices that are used for risk prediction. The following is the time series plot for EXCL.JK and ICBP.JK in the observation period:

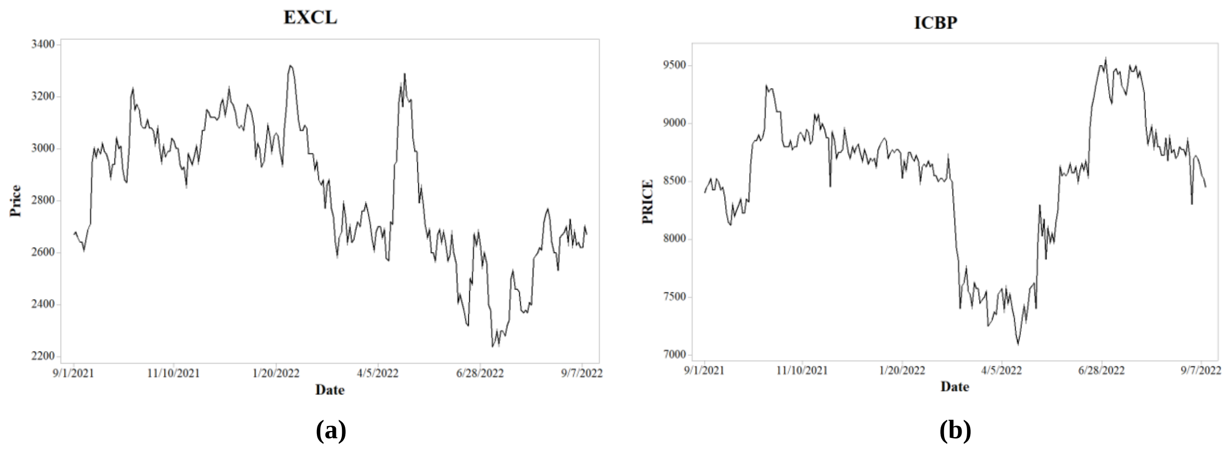


Figure 3. The daily closing price of (a) EXCL.JK; (b) ICBP.JK

Based on the time series plot in **Figure 1**, during the observation period the prices of EXCL.JK and ICBP.JK experienced fluctuations caused by various factors, either internal or external factors. During this period, several external factors that caused fluctuations in stock prices were the Indonesian government's economic recovery policy, natural disasters, and the war in Europe between Russia and Ukraine. Nevertheless, in general, the stock prices of EXCL.JK and ICBP.JK still tend to be stable and show a positive trend. Next, we will analyze the characteristics of stock prices based on the value of the descriptive statistics attached in the following table:

Table 1. Descriptive Statistics of EXCL.JK and ICBP.JK historical price

	Min	Max	Mean	St.dev	Skew	Kurtosis
EXCL.JK	2240	3320	2827.06	258.39	-0.2519	-0.8747
ICBP.JK	7100	9550	8550.50	574.91	-0.7450	-0.0319

Descriptive statistics of EXCL.JK historical price shows that the price average at the observation period is IDR 2827.06 with a standard deviation of 258.39. If compared to the 2020 average (IDR 2231.41), so EXCL.JK stock price experienced a significant increase. This increase is a positive impact of government policies to accelerate economic recovery after the COVID-19 pandemic. Based on the minimum and maximum values, it can be concluded that no data is more than the mean±3 standard deviation, this indicates that there are no outliers at the historical EXCL.JK price. Furthermore, for ICBP.JK we get the mean value is IDR 8550.50. standard deviation of ICBP.JK is greather than EXCL.JK implies that ICBP.JK has higher fluctuation. Then, at ICBK.JK it was concluded that there were no outliers because all data values were in the mean interval ±3st.dev.

After doing descriptive analysis, then we divide the data into 2 parts, estimation window and test window. In this study, the estimation window and test window length are 230 and 22 respectively. The illustration of the estimation and test window is as follows:

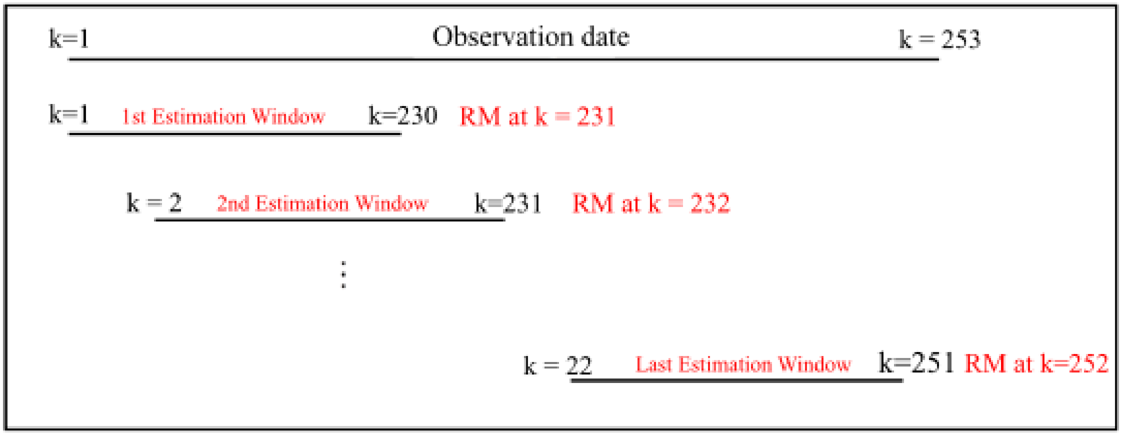


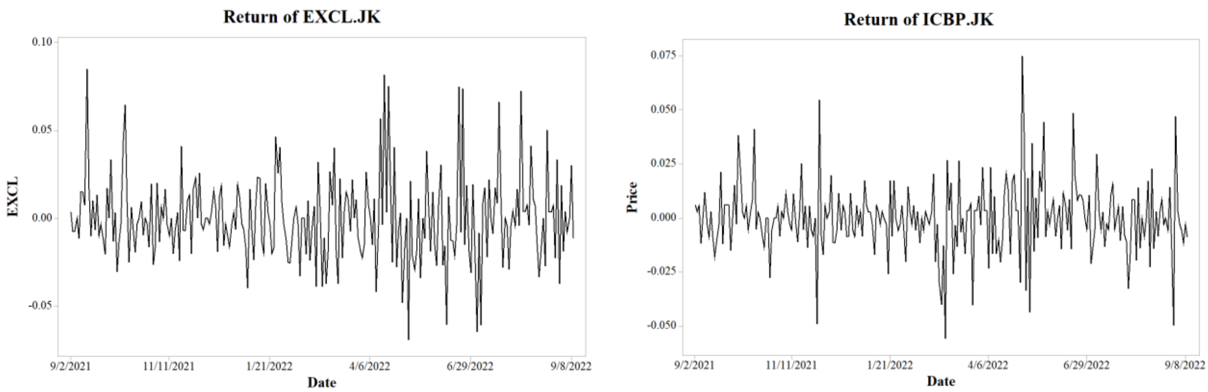
Figure 4. The illustration of estimation window and test window

After determining the length of the estimation window and the test window, then we will determine the return value obtained using the log-return method. This value will be used to form VaR and Adj-ES models. Here are descriptive statistics of in-sample return:

Table 2. Descriptive statistics of ICBP.JK and EXCL.JK return

	Min	Max	Mean	St. Dev	Skewness	Kurtosis
EXCL.JK	-0.0692	0.0848	1.396×10^{-18}	0.0241	0.6851	1.9043
ICBP.JK	-0.0558	0.0748	0.00002	0.0163	0.3597	3.1952

During the observation period, the maximum recorded profit on EXCL.JK share investment is 1.396×10^{-18} the average return has a positive value, meaning that the profits received are still greater than the losses incurred. The biggest loss recorded in the observation period was 6.92% and the maximum profit received was 8.48%. In ICBP.JK shares, the average profit is greater than EXCL.JK, with a value of 0.00002. The biggest profit recorded was 7.48% and the biggest loss was 5.58% of the total investment fund. A kurtosis value greater than 3 indicates that ICBP.JK's return is heavy tail, meaning there are extreme values or outliers in the data. The following is a plot of the return movement for the observation period:



(a) **(b)**

Figure 5. Time series plot of EXCL.JK and ICBP.JK return

Based on **Figure 5,** It is quite clear that in several periods, EXCL.JK and ICBP.JK experienced quite drastic price jumps, so it is very likely that there are outliers in the data. This argument is strengthened by the presence of data returns whose value is greater than the mean ± 3 st.dev.

Normality Test

This test aims to test whether the return data is normally distributed. This test is important to be carried out because the normality test results will be a reference for determining the approach used to predict the value of the risk of loss. Kolmogorov-Smirnov normality test results are attached in **Table 3**.

Table 3. Normality test of EXCL.JK and ICBP.JK return

Variable	KS-value	Sig
EXCL.JK	0.082	0.0057
ICBP.JK	0.112	0.0078

Based on **Table 3** and setting α = 5% we can conclude that EXCL.JK and ICBP.JK return is not normally distributed because Sig (0.0057 and 0.0078) is less than α (0.05). Eventually, the approach used to calculate the value of VaR and Adj-ES is nonparametric (with historical simulation).

Loss Risk Prediction using VaR and Adj-ES with Historical Simulation Approach

Risk prediction is useful as a reference in preparing the right risk management strategy. Predictions will be made in the test window by utilizing the return data in the corresponding estimation window. Because the return data is not normally distributed, the VaR and Adj-ES values prediction will be done with a nonparametric approach, that is, Historical Simulation (HS). The measurement of risk with VaR-HS begins with determining the value of the confidence level and holding period. In this study, we determined the 95% confidence level (α = 5%) and one-day holding period. The results obtained are as follows:

Table 4. Loss risk prediction using VaR-HS

Date	VaR-HS at 95% confidence level		Date	VaR-HS at 95% confidence level	
	EXCL.JK	ICBP.JK		EXCL.JK	ICBP.JK
8/10/2022	-0.0145	-0.1882	8/26/2022	-0.0100	-0.0133
8/11/2022	-0.0125	-0.0122	8/29/2022	-0.0276	-0.0082
8/12/2022	-0.0097	-0.0288	8/30/2022	-0.0104	-0.0188
8/15/2022	-0.0233	-0.0122	8/31/2022	-0.0287	-0.0233
8/16/2022	-0.0323	-0.0199	9/1/2022	-0.0122	-0.0221
8/18/2022	-0.0186	-0.0084	9/2/2022	-0.0140	-0.0321
8/19/2022	-0.0143	-0.0282	9/5/2022	-0.0100	-0.0100
8/22/2022	-0.0288	-0.0177	9/6/2022	-0.0311	-0.0097
8/23/2022	-0.0167	-0.0165	9/7/2022	-0.0144	-0.0152
8/24/2022	-0.0142	-0.0208	9/8/2022	-0.0120	-0.0392
8/25/2022	-0.0133	-0.0180	9/9/2022	-0.0200	-0.0421

Based on **Table 4**, the loss risk prediction for EXCL.JK and ICBP.JK have several results. The largest VaR value for EXCL.JK happened on 08/16/22 with the value is -0.0323, for the investors, it means that the maximum loss that they will face is 3.23% from their total investment fund. Then, for ICBP.JK, VaR on 09/09/22 became the biggest loss risk prediction with the value -0.0421. it means if investors put IDR 1,000,000 to invested on ICBK.JK, the maximum loss is IDR 42,100. After getting loss risk prediction using VaR-HS, the analysis will be continued with loss risk forecast by thorugh Adj-ES. We determined the α is 5% and c is 0.01, The result is given on following table:

Table 5. Loss risk prediction using Adj-ES risk measure

Date	**Adj-ES at α =5% and *c* =1**		**Date**	**Adj-ES at α =5% and *c* =1**	
	EXCL.JK	**ICBP.JK**		**EXCL.JK**	**ICBP.JK**
8/10/2022	-0.0228	-0.1965	8/26/2022	-0.0183	-0.0216
8/11/2022	-0.0208	-0.0205	8/29/2022	-0.0359	-0.0165
8/12/2022	-0.018	-0.0371	8/30/2022	-0.0187	-0.0271
8/15/2022	-0.0316	-0.0205	8/31/2022	-0.037	-0.0316
8/16/2022	-0.0406	-0.0282	9/1/2022	-0.0205	-0.0304
8/18/2022	-0.0269	-0.0167	9/2/2022	-0.0223	-0.0604
8/19/2022	-0.0226	-0.0365	9/5/2022	-0.0183	-0.0183
8/22/2022	-0.0371	-0.026	9/6/2022	-0.0594	-0.018
8/23/2022	-0.025	-0.0248	9/7/2022	-0.0227	-0.0235

8/24/2022	-0.0225	-0.0291	9/8/2022	-0.0203	-0.0475
8/25/2022	-0.0216	-0.0263	9/9/2022	-0.0283	-0.0504

Based on **Table 5**, the loss risk prediction for EXCL.JK and ICBP.JK has several results. The largest Adj-ES value for EXCL.JK happened on 08/06/22 with the value is -0.594, for the investors, it means that the maximum loss that they will face is 5.94% from their total investment fund. Then, for ICBP.JK, Adj-ES at 09/02/22 become the biggest loss risk prediction with the value -0.0604. it means if investors put IDR 10,000,000 to invested on ICBK.JK, the maximum loss is IDR 604,000

The main concept of the backtesting test is to measure the value of the Violation Ratio (VR), calculated based on the values of m_0 and η. The VaR and Adj-ES violation ratio calculation at the 95% confidence level was simulated on several values of estimated violation probability, namely 0.1%, 0.5%, 1%, 2%, 3%, 4% and 5%. With the help of software R 3.3.2, the obtained value of the ratio of violations is as follows:

Table 6. Violations ratio of VaR and Adj-ES on several violation probability

m_0	EXCL.JK		ICBP.JK	
	VR of VaR	VR of Adj-ES	VR of VaR	VR of Adj-ES
0,1%	1.98	0.12	2.21	0.22
0,5%	1.55	0.05	1.43	0.09
1%	1.21	0	1.08	0
2%	0.04	0	0.09	0
3%	0.02	0	0.06	0
4%	0	0	0.04	0
5%	0	0	0	0

Based on VR value in T**able 5**, Adj-ES was proven more accurate than VaR in terms of loss risk prediction, it was because of the VR of Adj-ES was less than VR of VaR and all of VR of Adj-ES < 1. So, the risk measure recommends for investors to predict loss risk is Adj-ES.

4. CONCLUSIONS

Based on the analysis done, the loss risk prediction, the loss risk prediction for EXCL.JK on 09/09/22 using VaR at 95% is -0.0200 or 2% from the total investment fund. Then, by using Adj-ES, the result in the same period is -0.0421. Then, the loss risk prediction for ICBP.JK on 09/09/22 using VaR at 95% is -0.0283 or 2.83% fromt the total investment fund. Then, by using Adj-ES, the result on the same period is -0.0504. By using the Backtesting test, the VR of VaR is greater than Adj-ES, in addition, there is no VR value on Adj-ES which is more than one. That result mean, numerically Adj-ES give more acurate result than VaR in term of risk prediction. Then, Adj-ES also proven fulfill subaditivity properties, which it become the limitation of VaR. So, we recommend to readers and investors to use Adj-ES than VaR when you will make loss risk prediction on the stock price investment.

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