



Optimal Stock Portfolio Analysis using Mean-Value at Risk (Mean-VaR) under Arbitrage Pricing Theory (APT)

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Abstract

Investing in Sharia-compliant stocks is one of the rapidly growing investment options, making it a potential choice for investors' portfolios. Therefore, investors need to understand how to select an optimal composition of stocks in their portfolio. This research aims to calculate the expected return on Sharia-compliant stocks and determine the optimal portfolio. The data used in this study includes stocks within the Indonesian Sharia Stock Index (ISSI) in the energy and mining sectors from November 1, 2022, to October 30, 2023. The analytical models employed are the Arbitrage Pricing Theory (APT) and Mean-Value at Risk (Mean-VaR). Based on the research findings, seven stocks form the composition of the optimal stock portfolio. These stocks are AKRA, ANTM, PGAS, INCO, INDY, PTBA, and MDKA, with weights of 20.54%, 19.58%, 19.02%, 14.24%, 10.97%, 8.00%, and 7.66%, respectively. The expected return for the investor is 0.13% per day, with a corresponding risk of 0.23%.

Keywords: Stock; Optimal Portfolio; ISSI; Arbitrage Pricing Theory; Mean-Value at Risk

1. Introduction

Investment in Islamic stocks is currently one of the investments that is now growing rapidly along with the expansion of the Islamic capital market. Indonesia Financial Services Authority or also known as Otoritas Jasa Keuangan (OJK) provides the latest news regarding the development of the number of Islamic stocks listed on the list of Islamic securities has continued to increase over the past six years (Data Indonesia, 2023). The number at the end of 2017 increased by 44.53% from 375 shares to 542 shares at the end of 2022. The highest growth in the number of Islamic stocks occurred in 2022, which increased by 11.98%. This shows that Islamic stocks have the potential to be chosen as an investor's portfolio.

An investor must pay attention to macroeconomic factors in returning investment decisions, such as world oil prices. Crude oil is one of the indicators of the global economy because of its volatility along with the political and economic development of a country (Fuad & Yuliadi, 2021). A country's capital market is affected by changes in world oil prices. The oil used as a standard to compare world oil prices is West Texas Intermediate (WTI). In addition, fluctuations in exchange rates, especially the value of the Rupiah against the US dollar, are things that must be considered by investors because they can have an impact on the potential value of shares (Nurmasari & Nur'aidawati, 2021). Extreme exchange rate fluctuations will have a negative impact on the business world because it will reduce the company's profit level and is expected to have an impact on the company's price. The representation of the Rupiah exchange rate transaction against the US Dollar carried out by Indonesian banks is the Jakarta Interbank Spot Dollar Rate (JISDOR). Interest rates are also a factor that must be considered, an increase in interest rates causes stock prices to decline (Nawindra & Wijayanto, 2020). The Bank Indonesia Certificate (also known as SBI in Indonesian) interest rate is an interest rate announced to the public as a monetary policy set by Bank Indonesia. Therefore, the WTI world oil price, JISDOR exchange rate, and SBI interest rate will be considered as macroeconomic factors to select stocks into the portfolio.

Arbitrage Pricing Theory (APT) is an alternative equilibrium model that uses various factors to identify the relationship between risk and return, an example of these factors is macroeconomic factors (Page, 1986). In its application, the APT model has not been able to determine the right weighting for each asset to minimize risk and maximize expected return, so another method is needed to support this research. The Mean-Variance (MV) model is a

model frequently utilized in portfolio optimization (Markowitz, 1952). The variety of MV models used in portfolio creation is growing, and Mean-Value at Risk (Mean-VaR) is one of the developing models. Portfolio formation using Mean-VaR is done by utilizing Value at Risk (VaR) and expected return for portfolio risk measurement.

This study uses daily stock closing data listed in the Indonesia Sharia Stock Index (ISSI) energy and mining sector, the index includes stocks that comply with sharia principles which are reviewed every six months. The existence of the energy sector is very important to increase state revenues, especially in terms of stock market investment (Nawindra & Wijayanto, 2020). In addition, the mining sector also has an important role in providing energy resources needed for the expansion of a country's economy, making it one of the cornerstones of such development (Hidayat & Sudjono, 2022). Research on stock portfolios conducted by Banihashemi & Navidi (2017) examines the measurement of the value of stock portfolio risk based on Mean-VaR. Then, Muchlish et al. (2023) examine the influence of macroeconomic factors such as exchange rates, interest rates, inflation, and world oil prices on the movement of the stock price index on the ISSI with multiple linear analysis. Then, Wahyuni & Gunarsih (2020) examined the differences in accuracy and analyzed the accuracy between the CAPM and APT models in predicting stock returns.

The difference between this research and previous research is that researchers combine the Mean-VaR model and Arbitrage Pricing Theory (APT). APT is used to select stocks that are included in the portfolio and Mean-VaR is used to determine the optimal weighting to minimize risk and maximize expected return. In addition, the research data used is different, namely ISSI stock data in the energy and mining sectors, as well as data on macroeconomic factors such as WTI world oil prices, JISDOR exchange rates, and SBI interest rates.

2. Literature Review

2.1. Stock Investment

Stocks are evidence of ownership of capital in a company. Stock returns are the results obtained from investment activities. Returns on stocks based on historical data in a certain time period can be calculated using equation (1).

$$R_{i,t} = \frac{P_{i,t} - P_{i(t-1)}}{P_{i(t-1)}}, \quad (1)$$

where $R_{i,t}$ is i -th stock return in period t , $P_{i,t}$ is closing price of stock in period t , and $P_{i(t-1)}$ is closing price of stock in period $(t - 1)$ (Bodie *et al.*, 2014). Based on equation (1), to find the value of the expected return, you can use equation (2).

$$\mu_i = \frac{\sum_{t=1}^n R_{i,t}}{n}, \quad (2)$$

where μ_i is expected return of the i -th stock, and n is number of periods observed. Every stock invested in is sometimes subject to risk. Statistical measures in the form of variance and standard deviation, denoted by σ_i , can be used to calculate the potential risk associated with an investment, namely by using the equation (3) and (4).

$$\sigma_i^2 = \frac{\sum_{t=1}^n (R_{i,t} - \mu_i)^2}{n}, \quad (3)$$

$$\sigma_i = \sqrt{\sigma_i^2}. \quad (4)$$

2.2. Arbitrage Pricing Theory (APT)

Arbitrage Pricing Theory (APT) is an asset price pricing model developed by Stephen A. Ross in 1976. The APT balance model is used to estimate the amount of risk that applies to an asset and the relationship between the expected return and the risk (Chisholm, 2003). Multifactor APT can generally be expressed in equation (5).

$$R_{i,t} = \alpha_i + \beta_{i1}R_{1,t} + \beta_{i2}R_{2,t} + \dots + \beta_{ik}R_{k,t} + \varepsilon_{i,t}, \quad (5)$$

where $R_{k,t}$ is factors that influence the k -th stock return in the t -th period and β_{ik} is coefficient that measures changes in the return of the i -th stock against changes in the k -th factor (Bodie *et al.*, 2014). To estimate the beta coefficient, you can use the Ordinary Least Square (OLS) principle, which is shown in equation (6).

$$\beta_i = (\mathbf{X}^T\mathbf{X})^{-1}(\mathbf{X}^T\mathbf{Y}), \quad (6)$$

where \mathbf{X} is independent variable is changes in the level of macroeconomic factors and \mathbf{Y} is dependent variable is stock return. Estimating the level of investment return requires careful consideration of the expected return. Equation (7) describes a balance model between the expected return and the systematic risk of each factor on a security.

$$\mu_{i(APT)} = R_f + \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \dots + \beta_{ik}\lambda_k, \quad (7)$$

where $\mu_{i(APT)}$ is expected return on stock using APT, R_f is return from securities with zero systematic risk (risk-free), $\beta_{i1,i2,\dots,ik}$ is sensitivity of stock returns to certain factors, and $\lambda_{1,2,\dots,k}$ is risk premium of the obtained factor $[\mu_F - R_f]$.

2.3. Investment Portfolio Optimization Based on Mean-VaR

VaR is defined as the maximum loss rate at a confidence level and over a certain time period obtained using the equation (8).

$$VaR_p = -(z_\alpha \sigma_p + \mu_p), \quad (8)$$

where VaR_p is value at risk of the portfolio, σ_p is portfolio's standar deviation, z_α is quantile $(1 - \alpha)$ of the return distribution with α representing the significant level, and μ_p is expected return of the portfolio (Sukono *et al.*, 2019). For example, w_i is the proportion of funds that will be allocated to stock i , so if all the funds are invested, then the total proportion is equal to 1. This can be represented in equation (9).

$$\sum_{i=1}^n w_i = \mathbf{e}^T \mathbf{w} = 1. \quad (9)$$

Based on equation (2.18), the return, expected return, and portfolio variance are shown in equations (10), (11), and (12), respectively.

$$R_p = \sum_{i=1}^n w_i R_i = \mathbf{w}^T \mathbf{R}, \quad (10)$$

$$\mu_p = \sum_{i=1}^n w_i \mu_i = \boldsymbol{\mu}^T \mathbf{w}, \quad (11)$$

$$\sigma_p^2 = \mathbf{w}^T \boldsymbol{\Sigma} \mathbf{w}, \quad (12)$$

where \mathbf{R} is column vector of returns, $\boldsymbol{\mu}$ is column vector of expected returns, and $\boldsymbol{\Sigma}$ is covariance matrix of stock returns. Based on equations (11) and (12), equation (8) can be written into equation (13).

$$VaR_p = -(z_\alpha \sigma_p + \mu_p) = -\left(z_\alpha (\mathbf{w}^T \boldsymbol{\Sigma} \mathbf{w})^{\frac{1}{2}} + \boldsymbol{\mu}^T \mathbf{w}\right). \quad (13)$$

The optimal portfolio can be obtained by maximizing the objective function (Banihashemi & Navidi, 2017).

$$\begin{aligned} & \text{Maximum } \{2\tau \mu_p - VaR_p\}, \\ & \text{subject to } \sum_{i=1}^N w_i = 1 \end{aligned} \quad (14)$$

where τ is risk tolerance. If the risk tolerance $\tau \geq 0$, the optimization problem must be solved by substituting equations (11) and (13) into equation (14), thus equation (15) is obtained.

$$\begin{aligned} & \text{Maximum } \left\{2\tau \boldsymbol{\mu}^T \mathbf{w} + z_\alpha (\mathbf{w}^T \boldsymbol{\Sigma} \mathbf{w})^{\frac{1}{2}} + \boldsymbol{\mu}^T \mathbf{w}\right\}, \\ & \text{subject to } \mathbf{e}^T \mathbf{w} = 1. \end{aligned} \quad (15)$$

Equation (15) is an optimization problem with constraints. Therefore, to obtain the optimal weights, it is necessary to define the Lagrange function shown in equation (16).

$$L(w, \lambda) = \left(2\tau \boldsymbol{\mu}^T \mathbf{w} + z_a (\mathbf{w}^T \boldsymbol{\Sigma} \mathbf{w})^{\frac{1}{2}} + \boldsymbol{\mu}^T \mathbf{w} \right) + \lambda (\mathbf{w} \mathbf{e}^T - 1), \quad (16)$$

where λ is Lagrange multiplier. Using the Kuhn-Tucker theorem, the optimization conditions are shown in equations (17) and (18).

$$\frac{\partial L}{\partial \mathbf{w}} = (2\tau + 1)\boldsymbol{\mu} + \frac{z_a (\boldsymbol{\Sigma} \mathbf{w})}{(\mathbf{w}^T \boldsymbol{\Sigma} \mathbf{w})^{1/2}} + \lambda \mathbf{e} = 0, \quad (17)$$

$$\frac{\partial L}{\partial \lambda} = \mathbf{e}^T \mathbf{w} - 1 = 0. \quad (18)$$

After solving equations (17) and (18), the investment portfolio weighting vector is obtained as shown in equation (19).

$$\mathbf{w} = \frac{(2\tau + 1)\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \lambda\boldsymbol{\Sigma}^{-1}\mathbf{e}}{(2\tau + 1)\mathbf{e}^T\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \lambda\mathbf{e}^T\boldsymbol{\Sigma}^{-1}\mathbf{e}}. \quad (19)$$

\mathbf{w} is the proportion of the portfolio with $\tau \geq 0$ (Sukono *et al.*, 2019). Where the inverse of matrix $\boldsymbol{\mu}$ is denoted by $\boldsymbol{\mu}^{-1}$. In addition, the multiplier value (λ) is obtained by solving the system equations (17) and (18), resulting in the equation (20).

$$\lambda_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \text{ with the condition } \lambda > 0, \quad (20)$$

where $a = \mathbf{e}^T \boldsymbol{\Sigma}^{-1} \mathbf{e}$, $b = (2\tau + 1)\mathbf{e}^T \boldsymbol{\Sigma}^{-1} \boldsymbol{\mu} + \boldsymbol{\mu}^T \boldsymbol{\Sigma}^{-1} \mathbf{e}$, and $c = (2\tau + 1)^2 \boldsymbol{\mu}^T \boldsymbol{\Sigma}^{-1} \boldsymbol{\mu} - z_a^2$.

3. Materials and Methods

3.1. Materials

In this study, the object is the stocks included in the Indonesian Sharia Stock Index (ISSI) energy and mining sector. The data used in this research is the daily closing price obtained through the page <https://finance.yahoo.com/>. In addition, this study also uses data on world oil prices West Texas Intermediate (WTI) obtained from the page <https://id.investing.com/>, JISDOR exchange rates and SBI interest rates obtained from <https://www.bi.go.id/>. The period used is November 1, 2022 to October 31, 2023 with 242 observations.

3.2. Methods

1. Making APT regression model assumptions referring to equation.
2. Analyzing the coefficient of determination, the F-test, and t-test between the dependent variable, namely stock returns, and the independent variable, namely macroeconomic factors.
3. Calculate expected returns, and variances based on the APT model.
4. Optimizing the portfolio using Mean-VaR

4. Result and Disussion

4.1. Assumptions of the Arbitrage Pricing Theory (APT) Model

The APT model in equation (5) is a time series regression equation used to calculate the sensitivity value, which is an assessment of the systematic risk of Islamic stock returns to macroeconomic factors. The return of each stock is the dependent variable, while the independent variables are macroeconomic factors. The APT model to be formed is shown in equation (21).

$$R_{i,t} = \alpha_i + \beta_{WTI,i} R_{WTI,t} + \beta_{JISDOR,i} R_{JISDOR,t} + \beta_{SBI,i} R_{SBI,t} + \varepsilon_{i,t}. \quad (21)$$

Based on equation (21) and using Microsoft Excel software, the α and β values of each stock against the three macroeconomic factors can be seen in Table 1.

Table 1: The α and β values of each stock against macroeconomic factors

Stock	α	β		
		WTI World Oil Price	JISDOR Exchange Rate	SBI Interest Rate
AKRA	0.00037	0.09862	-0.84945	0.02548
INDY	-0.00185	0.14026	-0.63957	0.04887
PGAS	-0.00163	0.14295	0.01459	-0.01992
ANTM	-0.00001	0.09891	-1.08469	0.00661
ESSA	-0.00202	0.08815	-0.26677	0.10375
INCO	-0.00097	0.14626	-0.65220	0.02048
MDKA	-0.00161	0.19323	-1.84055	-0.03446
ADRO	-0.00131	0.15960	-0.00773	0.01841
HRUM	0.00058	0.12234	-0.20727	0.01949
ITMG	-0.00176	0.11046	0.51187	0.05054
PTBA	-0.00146	0.14785	-0.15373	0.05330

The value of α indicates the value of stock returns without the influence of macroeconomic factors. If the value of α is positive, it indicates that there is a gain on the stock return. While a negative α value means that there is a loss on the stock return.

In addition, a positive β value indicates that stock movements are in the same direction as the macroeconomic factor. If the factor increases by 1 unit, the stock return will increase by its sensitivity value. Conversely, a negative β value indicates that the stock movement is the opposite of the macroeconomic factor. If there is a 1 unit increase in the factor, it will result in a decrease in stock returns by the sensitivity value.

4.2. Coefficient of Determination Analysis, F Test, and t Test

The value of the coefficient of determination, F -count, and t -count with the help of microsoft excel software is shown in Table 2.

Table 2 : Coefficient of determination, F -count, and t -count

Stock	R^2	F_{count}	t_{count}		
			WTI World Oil Price	JISDOR Exchange Rate	SBI Interest Rate
AKRA	0.041	3.385	1.570	-2.265	0.794
INDY	0.040	3.312	1.887	-1.442	1.288
PGAS	0.033	2.716	2.852	0.049	-0.778
ANTM	0.072	6.126	1.932	-3.549	0.253
ESSA	0.025	2.001	0.829	-0.420	1.911
INCO	0.071	6.036	2.977	-2.224	0.816
MDKA	0.101	8.894	2.672	-4.263	-0.933
ADRO	0.027	2.231	2.296	-0.019	0.518
HRUM	0.019	1.517	1.735	-0.493	0.541
ITMG	0.031	2.499	1.627	1.263	1.457
PTBA	0.037	2.998	2.063	-0.359	1.456

Referring to Table 2, the determination value R^2 obtained shows the magnitude of the influence of the three macroeconomic factors on stock returns based on the APT model and the rest shows the influence of other factors outside the study.

Based on the F -test conducted with the help of Microsoft Excel software, there are seven stocks that have a value of $|F_{count}| \geq |F_{table}|$ with a value of $F_{table} = 2.643$, so H_0 is rejected, which means that there is a simultaneous influence between the independent variables and the dependent variable. Stocks that have a value of $|F_{count}| < |F_{table}|$ namely stocks with codes ESSA, ADRO, HRUM, and ITMG mean that there is no simultaneous influence

between the independent variable and the dependent variable so that it will be discarded and will not be included in the calculation.

In addition, from the t test results, eight stocks are obtained which have a value of $|t_{count}| \geq |t_{table}|$ with a value of $t_{table} = 1.970$, so H_0 is rejected, this indicates that the independent and dependent variables are correlated. Conversely, stocks that have a value of $|t_{count}| < |t_{table}|$ value indicates that the independent and dependent variables do not correlate, namely stocks with the codes ESSA, HRUM, and ITMG so that they will be discarded and will not be included in the calculation. However, in the F test ADRO shares are proven to have no simultaneous influence so they will still be discarded and not included in the calculation.

4.3. Expected Return and Variance Based on APT

The expected return value and stock variance based on apt using the help of Microsoft Excel software, the results can be seen in Table 3.

Table 3 : Expected return and variance based on APT

Stock	$\mu_{i(APT)}$	σ_i^2
AKRA	0.0014	0.000019
INDY	0.0012	0.000026
PGAS	0.0007	0.000010
ANTM	0.0016	0.000023
INCO	0.0012	0.000021
MDKA	0.0020	0.000067
PTBA	0.0008	0.000022

Referring to Table 4, the expected return value of the seven stocks is positive, which means that these stocks consistently experience profits. The highest stock expected return was obtained by PT Merdeka Copper Gold Tbk (MDKA) of 0.0020, which means that PT Merdeka Copper Gold Tbk (MDKA) was able to achieve a profit level of 0.2% for 1 day.

Of the seven stocks, the highest stock risk occurs in PT Merdeka Copper Gold Tbk (MDKA) of 0.000067 or equivalent to 0.0067%. Meanwhile, the lowest stock risk is owned by PT Perusahaan Gas Negara Tbk (PGAS.JK) of 0.000010 or equivalent to 0.0010%.

4.4. Portfolio Optimization using Mean-VaR

Calculation weight of each stock (w_i), expected return, and VaR portfolio with the help of MATLAB software obtained results that can be seen in Table 4.

Table 4 : The value of each stock's weight, the portfolio's expected return, and the portfolio's VaR

τ	λ	$w1$	$w2$	$w3$	$w4$	$w5$	$w6$	$w7$	μ_p	VaR_p
0.00	0.00222	0.167	0.10	0.303	0.145	0.132	0.04	0.111	0.001127	0.002222
0.01	0.00221	0.167	0.100	0.302	0.146	0.132	0.042	0.111	0.001129	0.002222
0.02	0.00219	0.168	0.100	0.301	0.146	0.132	0.042	0.111	0.001130	0.002222
0.03	0.00218	0.168	0.100	0.300	0.147	0.132	0.043	0.111	0.001131	0.002222
0.04	0.00216	0.168	0.100	0.299	0.147	0.132	0.043	0.110	0.001132	0.002222
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
0.92	0.00005	0.205	0.109	0.192	0.195	0.142	0.076	0.081	0.001251	0.002338
0.93	0.00002	0.205	0.110	0.190	0.196	0.142	0.077	0.08	0.001253	0.002344

The VaR and expected return values obtained in Table 4 are interpreted in the graph, resulting in the efficient frontier graph shown in Figure 1.

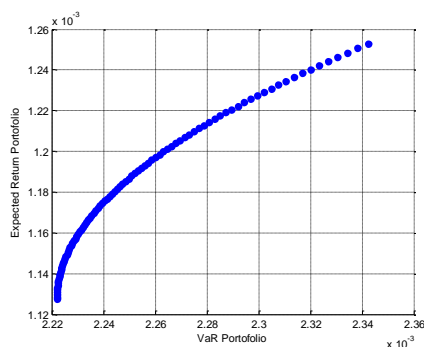


Figure 1 : Efficient frontier graph

Determination of the optimal portfolio is done by looking at the largest ratio of the expected return and VaR values. The ratio between the expected return and VaR of the portfolio is shown in Table 5.

Table 5 : Ratio between expected return and VaR

τ	μ_p	VaR_p	Ratio
0.00	0.001127	0.002222	0.507434
0.01	0.001129	0.002222	0.507928
0.02	0.001130	0.002222	0.508417
0.03	0.001131	0.002222	0.508901
0.04	0.001132	0.002222	0.509380
⋮	⋮	⋮	⋮
0.92	0.001251	0.002338	0.534860
0.93	0.001253	0.002344	0.534874

The optimal portfolio graph is by combining the ratio value and VaR can be seen in Figure 2.

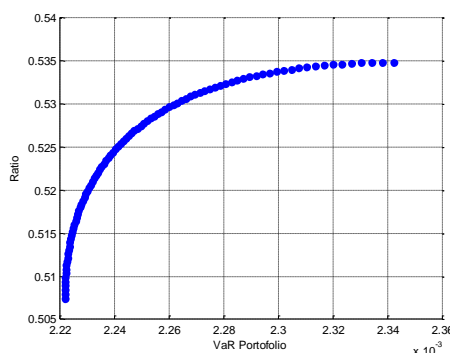


Figure 2 : Optimal portfolio graph

5. Discussion

The efficient portfolio is located along the line with risk tolerance between $0 \leq \tau \leq 0.93$. The risk tolerance value $\tau > 0.93$ cannot be continued because it does not meet the condition $\lambda > 0$ so the optimization process is stopped. An increase in the risk tolerance value results in an increase in the expected return value of the portfolio, as well as an increase in VaR.

The highest ratio obtained is 0.534874 when $\tau = 0.93$, which means that the optimal portfolio is obtained with weights from largest to smallest, namely AKRA, ANTM, PGAS, INCO, INDY, PTBA, and MDKA shares of 20.54%, 19.58%, 19.02%, 14.24%, 10.97%, 8.00%, and 7.66% respectively. Based on these weights, the expected return is 0.0013 and the risk level is 0.0023. This indicates that the risk of the portfolio formed is very minimal at 0.23%, so it can be a safe choice for investors in making investments.

6. Conclusion

Based on the results of calculations using the APT model, seven stocks are included in the portfolio formation. In addition, portfolio optimization using Mean-VaR results in the weight of AKRA, ANTM, PGAS, INCO, INDY, PTBA, and MDKA shares of 20.54%, 19.58%, 19.02%, 14.24%, 10.97%, 8.00%, and 7.66%, respectively. Expected return on the stock portfolio that will be obtained by investors is 0.13% per day with the risk borne by 0.23%.

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