MARKET RISK MEASUREMENT OF SHARIA STOCK PORTFOLIOS USING MONTE CARLO–BASED VAR: EVIDENCE FROM AN INDONESIAN SHARIA INSURANCE COMPANY

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Abstract

This study aims to evaluate the investment risk of PT A's sharia stock portfolio during the period of May-August 2025 using the Value at Risk (VaR) approach. The research sample consists of nine stocks listed in the Sharia Securities List (DES), comparing the Parametric VaR and Monte Carlo Simulation methods in measuring the aggregate risk of cross-sector portfolios. The results show that the Monte Carlo approach produces risk estimates that are more responsive to abnormal return distributions and contain fat tail phenomena compared to the parametric method. Based on validity testing (backtesting), the Monte Carlo VaR model is statistically valid at a 95% confidence level with a VaR value of −2.74%, but it is not valid at a 99% confidence level because it fails to capture extreme price movements. These findings indicate that even though diversification has been applied, PT A's portfolio risk remains higher than the sharia market risk due to weight concentration in volatile sectors such as petrochemicals and minerals. Therefore, 95% VaR is recommended as the basis for determining daily operating capital reserves in order to maintain the Risk-Based Capital (RBC) ratio above the minimum regulatory limit set by the Financial Services Authority of 120%, while continuing to supplement risk measurement through additional risk mitigation in extreme market conditions.

Keywords: *Market Risk, Sharia Portofolio, Value at Risk, Monte Carlo Simulation, Diversification*

Abstrak

Penelitian ini bertujuan untuk mengevaluasi risiko investasi portofolio saham syariah PT A selama periode Mei-Agustus 2025 menggunakan pendekatan Value at Risk (VaR). Sampel penelitian terdiri atas sembilan saham yang tergabung dalam Daftar Efek Syariah (DES), dengan perbandingan antara metode Parametric VaR dan Monte Carlo Simulation dalam mengukur risiko agregat portofolio lintas sektor. Hasil penelitian menunjukkan bahwa pendekatan Monte Carlo menghasilkan estimasi risiko yang lebih responsif terhadap distribusi return yang tidak normal dan mengandung fenomena fat tails dibandingkan metode parametrik. Berdasarkan uji validitas (backtesting), model VaR Monte Carlo dinyatakan valid secara statistik pada tingkat kepercayaan 95% dengan nilai VaR sebesar −2,74%, namun tidak valid pada tingkat kepercayaan 99% karena gagal menangkap pergerakan harga ekstrem. Temuan ini mengindikasikan bahwa meskipun diversifikasi telah diterapkan, risiko portofolio PT A tetap lebih tinggi dibandingkan risiko pasar syariah akibat konsentrasi bobot pada sektor volatil seperti petrokimia dan mineral. Oleh karena itu, VaR 95% direkomendasikan sebagai dasar penentuan cadangan modal operasional harian guna menjaga rasio Risk-Based Capital (RBC) di atas batas minimum regulasi yang ditetapkan oleh Otoritas Jasa Keuangan sebesar 120%, dengan tetap melengkapi pengukuran risiko melalui mitigasi risiko tambahan pada kondisi pasar ekstrem.

Kata Kunci: *Risiko Pasar, Portofolio Syariah, Value at Risk, Simulasi Monte Carlo, Diversifikasi*

INTRODUCTION

The capital market is a vital instrument in accelerating the national economy, bridging the needs of corporate expansion with opportunities for investor wealth development (Mubarok et al., 2017). For sharia insurance companies, the capital market is not merely an investment vehicle, but a key component of tabarru' fund management and participant investment. One of the strategies or methods used by sharia insurance companies to invest for business sustainability is to place their investment portfolios in the capital market. However, investment activities always face risks, especially market risks due to stock price fluctuations (Bodie et al., 2021). In the Islamic insurance ecosystem, failure to manage market risk not only threatens the solvency of the company, but also damages the trust of policyholders and compliance with principles (Addini et al., 2024; Cahyandari et al., 2023; Faizuddin et al., 2024).

PT A, as one of Indonesia's sharia insurance companies, plays a strategic role as an institutional investor in managing tabarru' funds and participant investments. The management of investment portfolios in instruments listed in the Sharia Securities List (DES) requires a high level of precision in maintaining financial performance and adequacy of solvency levels as reflected in Risk-Based Capital (RBC) (Robbyah et al.,

2021). Along with the increasing role of the Islamic insurance industry in Indonesia, the need for more effective investment risk management is becoming more urgent. Islamic insurance companies not only function as risk management institutions for the community, but also as institutional investors that place most of their funds in capital market instruments, including stocks (Herawati, 2024; Financial Services Authority of the Republic of Indonesia, 2024). Several studies show that the financial performance of Islamic insurance is greatly influenced by investments, premiums, and claims, making investment risk management a key factor in maintaining solvency (Abduh & Isma, 2017; Haerani & Kholis, 2024; Haniatur Rofika & Kurniawati Meylianingrum, 2024).

An important quantitative method used in measuring market risk is Value at Risk (VaR) (Heryanti, 2017). The concept of VaR has become a global standard in risk measurement because it provides an estimate of the maximum loss that may occur within a certain period of time with a certain level of confidence (Klugman A. et al., 2012). Several studies confirm the relevance of VaR in market risk management in various financial sectors, including banking and insurance (Parodi, 2022).

Although the literature on Islamic insurance risk management has grown rapidly, observations of the current discourse reveal a tendency to focus exclusively on macro performance and operational resilience (Chong et al., 2024; Herawati, 2024). This phenomenon leaves an analytical gap at the micro portfolio level, particularly in understanding the extent to which the weighting of individual assets contributes to collective risk reduction in Islamic insurance companies. In stable market conditions where stock returns tend to follow a normal distribution, the main challenge for Islamic insurance investment managers is determining the accuracy of estimates of maximum potential losses. Although standard parametric approaches can be used, the use of Monte Carlo simulation remains crucial as a stochastic validation tool. This simulation allows companies to model thousands of future price path scenarios that cannot be captured by one-dimensional static calculations.

This study aims to evaluate the effectiveness of an Islamic insurance company's investment strategy by comparing the Value at Risk (VaR) of individual stocks to the VaR of weighted portfolios. By integrating the Monte Carlo process, this study aims to empirically prove whether the diversification applied has reached the optimal point in

maintaining solvency stability, while providing accurate loss projections through thousands of random iterations that reflect actual market dynamics.

RESEARCH METHOD

This study applies an explanatory quantitative approach to analyze market risk in PT A's investment portfolio. The data used is secondary data in the form of daily closing prices obtained from Yahoo Finance through the yfinance library in Python programming. The research population includes all securities in the Sharia Securities List (DES) for the period of May 2025 based on the Decree of the OJK Board of Commissioners Number KEP-28/D.04/2025. Purposive sampling was used to determine the sample, with the main criteria being the nine sharia stocks actually owned by PT A as of August 2025, namely ANTM.JK, ASII.JK, BRPT.JK, BRMS.JK, TPIA.JK, ICBP.JK, PANI.JK, TLKM.JK, and UNTR.JK. The observation period was set for two years (October 2023 to October 2025) or approximately 500 trading days. This duration was chosen with reference to Jorion (2007) in order to balance the availability of sufficient statistical data with the relevance of current market conditions in accordance with the standards of the Basel Committee on Banking Supervision (BCBS).

To ensure the validity of the analysis, all asset prices were transformed into logarithmic returns to guarantee data stationarity. The analysis process began with structuring the portfolio based on proportional investment weights for each asset. Next, risk estimates were calculated using two comparative methods: Parametric Value at Risk (VaR) and Monte Carlo VaR. In the parametric method, risk is projected using a variance-covariance model with normal distribution assumptions, where the VaR value is derived from multiplying the Z-score at a certain confidence level by the aggregate portfolio volatility. As the main comparison, Monte Carlo simulations are run by generating 10,000 stochastic return scenarios to illustrate various possible future market movements. Unlike linear models, the VaR cut-off point in this simulation is determined through empirical percentile techniques at confidence levels of 90%, 95%, and 99%.

The final stage of the research involves a backtesting procedure using Kupiec's Proportion of Failures (POF) test to examine the reliability of the model. This step aims to validate the number of exceptions that is, conditions where actual losses exceed the VaR estimate to ensure they remain within statistical tolerance limits. The model is

considered to have high accuracy or validity if the Likelihood Ratio (LR) value produces a P-Value that indicates no significant difference between the actual failure frequency and the expectation at a 5% significance level. Through the integration of this methodology, it is hoped that the most representative risk estimates will be obtained as a basis for strategic decision-making for PT A.

RESULT AND DISCUSSION

1. Data Description

The research data consists of daily stock prices of companies listed on the Sharia Securities List (DES) for the period of May 2025. From this population of stocks, stocks used as investment instruments at PT A in August 2025 were selected. The list of sample stocks is shown in Table 1.

Table 1. List of Sample Stocks

No	Saham	Bobot	Sektor/Industri
1	Aneka Tambang Tbk. (ANTM)	0,03	Mining / Minerals (Metals & Minerals)
2	Astra Internasional Tbk. (ASII)	0,11	Automotive / Manufacturing Industry and Construction Services
3	Barito Pacific Tbk. (BRPT)	0,03	Chemical Materials / Petrochemicals & Energy
4	Bumi Resources Minerals Tbk.(BRMS)	0,03	Metals & Minerals / Mineral Mining
5	Chandra Asri Pacific Tbk.(TPIA)	0,09	Petrochemicals / Chemical Industry
6	Indofood CBP Sukses Makmur Tbk. (ICBP)	0,03	Konsumer/ Makanan & Consumer Goods / Food & Beverages
7	Pantai Indah Kapuk Dua Tbk. (PANI)	0,04	Property / Real Estate
8	Telkom Indonesia (Persero) Tbk. (TLKM)	0,16	Telecommunications / Digital Infrastructure & Telecommunications
9	United Tractors Tbk. (UNTR)	0,04	Heavy Equipment, Mining & Construction / Heavy Industry, Mining & Energy

The composition of the analyzed stock portfolio shows a relatively good level of cross-sector diversification. The sector with the largest weight is Telkom Indonesia (16%) from the telecommunications industry, which is known as a defensive sector and plays an important role in supporting national digital transformation (Rakhman & Nurhasanah, 2022). Furthermore, large allocations are found in Astra International (11%) from the automotive and manufacturing sector, as well as Chandra Asri Pacific (9%) which is engaged in petrochemicals. This indicates that the portfolio is oriented towards a combination of the digital infrastructure, automotive, and chemical-based energy sectors, which have medium to long-term growth prospects.

Additionally, the portfolio is diversified across the commodities sector through Aneka Tambang, Bumi Resources Minerals, and United Tractors, with an average weighting of 3–4 percent per stock. Exposure to this sector offers high profit potential but also increases sensitivity to global price volatility in metals, minerals, and energy. At the same time, the consumer sector through Indofood CBP (3%) and the property sector through Pantai Indah Kapuk Dua (4%) provide a balancing element that tends to be more stable against external shocks. Diversification into the consumer and property sectors is important because these sectors are relatively resilient in the face of market uncertainty (Sinaga et al., 2022).

The stock price experienced significant fluctuations during the last two-year observation period, as shown in Figure 1. This fluctuation pattern indicates high market volatility and forms the basis for portfolio risk measurement.

Figure 1. Stock Price Movement

According to Figure 1., stock price movements over the past two years show varying dynamics among issuers in the portfolio. United Tractors (UNTR.JK) shares rank highest with a closing price consistently above IDR 20,000 and a tendency to increase, reflecting strong fundamentals in the heavy equipment and mining sectors. Telkom Indonesia (TLKM.JK) and Astra International (ASII.JK) appear stable with moderate fluctuations in the range of Rp6,000–Rp10,000, indicating defensive stock characteristics in the telecommunications and automotive sectors. Meanwhile, Chandra Asri Pacific (TPIA.JK) experienced quite high volatility, especially in 2024 to early 2025, which illustrates the petrochemical industry's sensitivity to changes in global energy prices.

Shares of Aneka Tambang (ANTM.JK), Barito Pacific (BRPT.JK), and Bumi Resources Minerals (BRMS.JK) showed relatively volatile trends with lower prices compared to big-cap stocks, consistent with the characteristics of the mining and minerals sector, which is highly influenced by commodity price movements. Indofood CBP (ICBP.JK) shows a stable upward trend, reflecting the resilience of the consumer sector to market shocks. On the other hand, Pantai Indah Kapuk Dua (PANI.JK) shows a significant increase in the mid-2024 to early 2025 period, in line with the growth prospects of the property sector.

Daily returns are calculated using the logarithmic return approach. The results show that the average daily return of most stocks is positive, but with a fairly large standard deviation. This indicates the opportunity for profit, but also carries a significant risk of fluctuation. A summary of the descriptive statistics is shown in Table 2.

Table 2. Descriptive Statistics of Daily Returns for Each Stock

	ANTM	ASII	BRPT	BRMS	TPIA	ICBP	PANI	TLKM	UNTR
mean	0.001426	0.000248	0.002038	0.002551	0.002326	-0.000187	0.002176	-0.000109	0.000311
std	0.028481	0.017112	0.044470	0.039104	0.044465	0.018318	0.042856	0.019546	0.018893
min	-0.155171	-0.093685	-0.200671	-0.156161	-0.223143	-0.092932	-0.221788	-0.063179	-0.158406
25%	-0.013699	-0.009816	-0.020228	-0.018245	-0.014358	-0.009518	-0.017157	-0.011407	-0.009671
50%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001033
75%	0.016129	0.009581	0.021553	0.017834	0.017350	0.009694	0.018084	0.010601	0.009199
max	0.099922	0.094858	0.221237	0.161119	0.223144	0.095310	0.223144	0.070793	0.065454

Based on Table 2, it shows that mean return of most stocks recorded positive values, with BRMS (0.2551%), BRPT (0.2038%), and TPIA (0.2326%) as the main contributors to the portfolio's potential returns. Conversely, ICBP (-0.0187%) and TLKM (-0.0109%) show negative average values, which can suppress overall return expectations.

In terms of volatility (standard deviation), commodity-based stocks such as BRPT (4.45%) and TPIA (4.45%) have the highest level of fluctuation risk, followed by BRMS (3.91%). This indicates that although these stocks offer greater profit opportunities, investors must be prepared to face high uncertainty. Conversely, ASII (1.71%), ICBP (1.83%), and UNTR (1.89%) stocks exhibit relatively low volatility, making them more stable but potentially offering smaller returns.

The minimum return value indicates the potential for extreme losses, with TPIA (-22.31%), PANI (-22.17%), and BRPT (-20.06%) as the stocks with the greatest downside risk. On the other hand, the maximum return value indicates significant profit potential, for example BRPT (22.12%), PANI (22.31%), and TPIA (22.31%). This illustrates an asymmetric return distribution with fat tails, confirming that extreme price movements remain possible during the daily trading period.

The distribution of daily returns is visualized in Figure 2, which shows that the return data is not completely symmetric and has fat tails. This condition indicates that extreme risks (large losses or gains) are still possible.

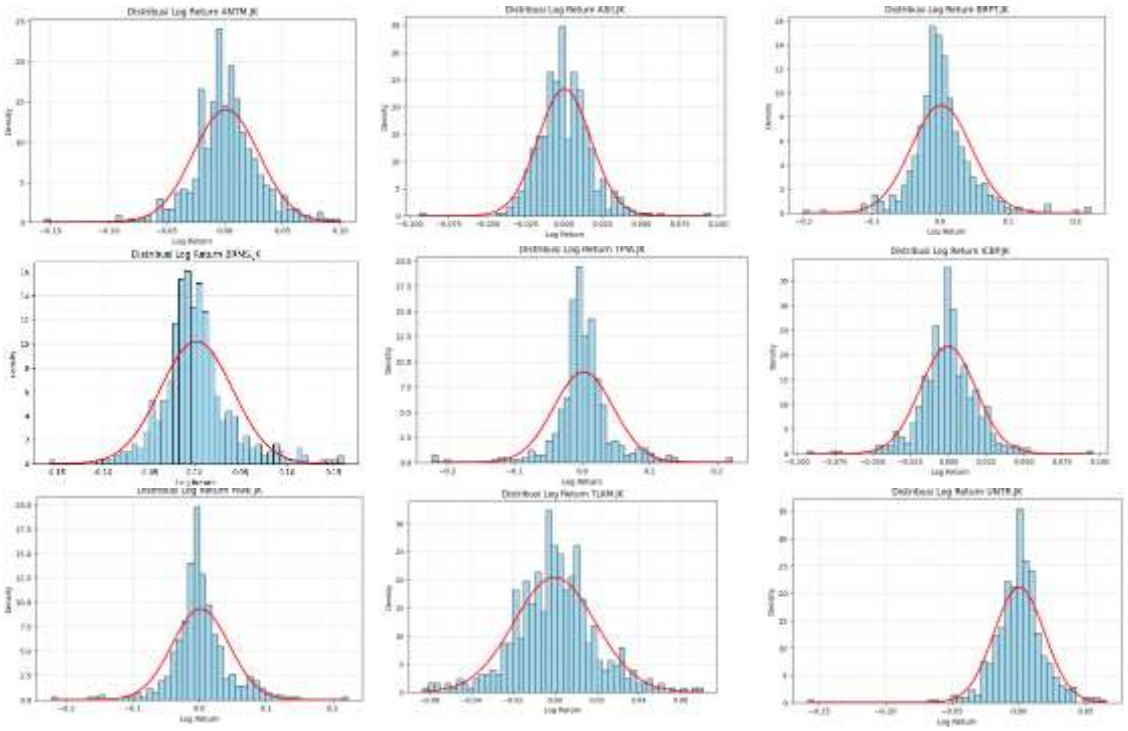

Figure 2. Distribution of Daily Stock Returns

2. Data Stationarity Test (ADF Test)

A stationarity test using Augmented Dickey-Fuller (ADF Test) was conducted to ensure that the return data did not contain unit roots. The test results showed that all stock return data had a p-value < 0.05, so it can be concluded that daily returns are stationary. This is important because variance-covariance-based risk analysis requires stationary data.

3. Average Return Analysis and Covariance Matrix

The results of the average return and standard deviation calculations for each stock are shown in Table 4. In general, most stocks show a positive average return, although there are variations between issuers. This reflects that the portfolio has profit potential, but the level of risk varies according to the volatility of each stock.

Meanwhile, the estimated covariance matrix between stocks is shown in a heatmap visualization in Figure 5. This covariance matrix provides an overview of the relationship between return movements between stocks in the portfolio. Most stock pairs show relatively small covariance values close to zero, indicating that the relationship between return movements is weak. This condition indicates that

portfolio diversification has the potential to be effective in reducing risk because returns between stocks do not move entirely in the same direction.

However, there are several stock pairs with higher positive covariance values, such as BRMS–BRPT and TPIA–PANI. This indicates a tendency for more aligned price movements in these stock pairs. Conversely, other pairs that show very small covariance values, even close to zero, reflect the independence of return movements that can be utilized to strengthen the diversification effect.

Figure 5. Heat Map of Inter-Stock Covariance Matrix

4. Comparative Analysis of Parametric and Monte Carlo Value at Risk (VaR)

Table 6. Comparison of Individual VaR: Parametric vs. Monte Carlo

Code	VaR (90%)		VaR(95%)		VaR (99%)	
	Parametric	Monte Carlo	Parametric	Monte Carlo	Parametric	Monte Carlo
ANTM	-3.66%	-3.55%	-4.70%	- 4.58%	-6.65%	- 6.49%
ASII	-2.20%	-2.19%	-2.82%	-2.81%	-3.99%	-3.95%
BRMS	-5.11%	- 4.86%	-6.56%	-6.31%	-9.28%	-8.96%
BRPT	-5.69%	-5.51%	-7.30%	-7.12%	-10.32%	-10.08%
ICBP	-2.36%	-2.40%	-3.03%	-3.07%	-4.28%	-4.30%
PANI	-5.49%	-5.32%	-7.05%	-6.87%	-9.97%	-9.73%
TLKM	-2.50%	-2.54%	-3.21%	-3.25%	-4.55%	-4.55%
TPIA	-5.70%	-5.51%	-7.31%	-7.13%	-10.34%	-10.09%
UNTR	-2.42%	-2.41%	-3.11%	-3.10%	-4.40%	-4.36%

Based on Table 6, the results of individual VaR estimates show significant differences in risk levels between stocks, with assets such as BRPT and TPIA consistently recording the highest parametric VaR values, namely -10.32% and -10.34% at a 99% confidence level. This finding is in line with Husnan's (2015) research, which shows that stocks with high volatility and cyclical characteristics, such as the energy and petrochemical sectors, tend to dominate individual risk in the Indonesian capital market. The concentration of risk in certain assets is also consistent with Al Janabi's (2014) findings on sharia portfolios, which confirm that risk is not evenly distributed due to the unique characteristics of each issuer. Methodologically, the Monte Carlo simulation in this study produced more efficient values than the parametric approach. This supports Jorion's (2007) argument that parametric VaR tends to be overestimated due to the assumption of a normal distribution, while Monte Carlo is more adaptive to real market data. However, as noted by Abad et al. (2014), both methods remain dependent on historical volatility, which can cause estimation bias when systemic risk occurs.

5. Analisis VaR Agregat Portofolio dan Validasi Model

At the aggregate portfolio level, the recapitulation results show diversification efficiency, where the overall portfolio risk is much lower than the risk of individual assets. The recapitulation of PT A's portfolio VaR analysis is presented in Table 6 below:

Table 6. Recapitulation of Aggregate Portfolio VaR Analysis and Validity Test Results (Backtesting)

CL (%)	VaR Parametrik	VaR Monte Carlo	VaR JII	Exceptions	P-Value	Status
90	-2.21%	-2.11%	-1.58%	30	0.0050	Invalid
95	-2.83%	-2.74%	-2.03%	21	0.5761	Valid
99	-4.01%	-3.88%	-2.99%	10	0.0336	Invalid

Based on Table 6, at the aggregate portfolio level, the Monte Carlo VaR value ranges from -2.11% to -3.88%. When compared with the comparative data, the Monte Carlo VaR value at all confidence levels consistently shows a higher level of risk than

the JII VaR, which only ranges from -1.58% to -2.99%. These findings indicate that even though diversification of nine sharia stocks has been carried out in accordance with Markowitz's theory (1952), the risk profile of PT A's sharia stock portfolio during the observation period is still higher than the sharia market risk represented by JII.

The high VaR of the stock portfolio is due to the relatively concentrated asset allocation structure, as shown in Table 1 and Table 2. The portfolio is dominated by highly volatile stocks such as TPIA (9%), BRPT (3%), and BRMS (3%), while the contribution of defensive stocks such as ICBP (3%) is not strong enough to offset this risk. This indicates that even though a diversification strategy has been implemented, the characteristics of the selected sharia assets still tend to be high risk, so that the portfolio's risk level exceeds the average market risk during the research period.

The backtesting results show that the Monte Carlo VaR model is only declared Valid at a 95% confidence level with a VaR value of -2.74% and a p-value of 0.5761. Conversely, at confidence levels of 90% and 99%, the model shows an Invalid status because the number of exceptions that occurred did not meet the statistical testing criteria. The failure at CL 90% indicates that the model tends to underestimate, while at CL 99% the model fails to capture data extremes. The invalidity of the Monte Carlo model at a confidence level of 99% (with 10 exceptions) indicates the phenomenon of fat tails in the distribution of Islamic stock returns during the period May-August 2025. This indicates that standard simulation models tend to underestimate extreme risks or black swan events that exceed normal market fluctuations.

For PT A, this finding implies that the use of 95% VaR (-2.74%) is sufficient for daily operating capital reserves to meet the Risk-Based Capital (RBC) ratio. Based on OJK regulations in Indonesia, insurance companies are required to maintain a minimum solvency level of 120%. If the VaR value at extreme levels fails to be predicted, there is a risk of unanticipated capital depletion that could threaten the company's financial health.

CONCLUSION

Based on the results of risk analysis using the Value at Risk (VaR) method on PT A's sharia stock portfolio for the period May-August 2025, it can be concluded that the

portfolio structure has heterogeneous risk characteristics with volatility dominating in certain sectors. The findings show that even though the portfolio has been diversified into nine stocks from various sectors, risk concentration remains centered on assets with high sensitivity to global commodity prices, such as TPIA, BRPT, and BRMS. These stocks recorded the highest individual VaR values, confirming that the petrochemical and mineral sectors remain the main contributors to tail risk in the Indonesian sharia capital market. On the other hand, the presence of defensive stocks such as ICBP and TLKM has proven to have a balancing effect, although it is not yet strong enough to reduce the aggregate risk of the portfolio below the market risk level (JII).

Methodologically, this study proves that the Monte Carlo simulation approach produces risk estimates that are relatively more adaptive than parametric methods. This is due to Monte Carlo's ability to accommodate the abnormal distribution of sharia stock returns and the phenomenon of fat tails, where extreme price movements occur more frequently than predicted by a normal distribution. However, the validity test results through backtesting show that the Monte Carlo model is only valid at a 95% confidence level with a VaR value of -2.74%. The failure of the model at the 90% and 99% confidence levels indicates the existence of market anomalies or black swan events during the observation period that exceed the limits of standard statistical estimates, so that the model tends to underestimate risk at extreme levels.

The managerial implications of these findings emphasize the importance for PT A to use VaR figures at a 95% confidence level as the basis for daily capital reserves in order to maintain a Risk-Based Capital (RBC) ratio in accordance with OJK regulations of 120%. Given the invalidity of the model at a 99% confidence level, the company is advised not to rely solely on the standard VaR model for risk mitigation, but also to integrate stress testing on a regular basis. This is crucial to anticipate unexpected volatility spikes in commodity and property sector stocks, so that the company's financial health is maintained amid the dynamic uncertainty of the Islamic capital market. Thus, Islamic stock portfolio risk management requires an approach that is not only based on historical statistics, but also sensitive to market structural dynamics and sectoral characteristics.

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