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A Decision-Centric Approach to Risk Management in Aviation Stock Investments Using Value at Risk and Portfolio Optimization

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Abstract

This study applies Monte Carlo simulation to analyze and compare the Value at Risk (VaR) of two Indonesian airline stocks—PT Garuda Indonesia (full-service carrier) and PT AirAsia Indonesia (low-cost carrier)—using daily return data from January to December 2023. The research examines risk-return characteristics at individual stock and portfolio levels across different confidence intervals (99%, 95%, and 90%). Results reveal that PT Garuda Indonesia exhibits higher expected returns (0.5168%) but also higher volatility (3.5980%) compared to PT AirAsia Indonesia (0.2412% return, 2.4868% volatility), reflecting their different business models. Remarkably, an equal-weight portfolio demonstrates extraordinary diversification benefits, with positive VaR values across all confidence levels, indicating robust downside protection even in adverse market conditions. At 99% confidence, the monetary VaR for a Rp100,000,000 investment shows potential maximum losses of Rp7,984,331 for Garuda and Rp5,460,951 for AirAsia, while the portfolio generates a minimum gain of Rp1,886,373. This study highlights the effectiveness of Monte Carlo VaR in capturing complex risk dynamics, demonstrates significant intra-sector diversification benefits challenging conventional diversification wisdom, and provides insights into how different airline business models translate into distinctive risk-return profiles. These findings have important implications for investment decision-making and risk management in specialized industry contexts, particularly in emerging markets.

Keywords: Value at Risk; Monte Carlo simulation; airline industry; portfolio diversification; risk management; business models

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1. Introduction

The aviation industry represents a critical component of economic infrastructure, particularly in archipelagic nations like Indonesia where air transportation serves as a vital link between islands, facilitating business activities and tourism. In financial markets, airline stocks offer unique investment opportunities characterized by distinctive risk-return profiles influenced by multiple factors including fuel price volatility, regulatory changes, economic cycles, and competitive dynamics. The application of sophisticated statistical approaches to analyze airline stock performance provides essential insights for investors navigating this complex sector, where traditional risk assessment methods may inadequately capture the nuanced risk characteristics inherent in aviation investments. The comparative analysis of PT Garuda Indonesia and PT AirAsia Indonesia, representing different business models within the same industry, offers a valuable case study for examining how quantitative risk management methodologies can enhance investment decision-making in specialized industry contexts (Campbell et al., 2001; Yu et al., 2020).

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Indonesian airline stocks present distinctive investment characteristics shaped by the country's geographic configuration and economic development trajectory. The aviation sector in Indonesia has experienced significant growth over the past decade, driven by increasing domestic tourism, business travel, and improved economic conditions. However, this growth has been accompanied by challenges including intense competition, regulatory complexities, and sensitivity to macroeconomic factors. The significance of applying advanced risk measurement techniques such as Value at Risk (VaR) with Monte Carlo simulation to Indonesian airline stocks lies in the ability to capture the complex risk dynamics specific to this market segment, providing investors with more accurate risk estimates compared to conventional methods that assume normal distribution of returns. This methodological approach offers particular value for emerging market contexts where return distributions often exhibit non-normal characteristics, including fat tails and skewness (Sharma & Shekhawat, 2022; Schuhmacher et al., 2021).

PT Garuda Indonesia, the national flag carrier, and PT AirAsia Indonesia, part of the regional low-cost carrier group, represent contrasting business models within the Indonesian aviation sector. Garuda Indonesia operates primarily as a full-service carrier with a focus on premium service, while AirAsia Indonesia adopts a low-cost model emphasizing operational efficiency and competitive pricing. The comparative analysis of these companies provides an opportunity to examine how different business strategies within the same industry translate into distinctive risk-return profiles, offering insights into the relationship between business models and financial market performance. This industry-specific analysis contributes to the literature on sector-based investment strategies, highlighting how quantitative risk assessment can be tailored to specific industry dynamics (Rajyaguru, 2023; Chen et al., 2014).

The application of portfolio theory to airline stocks introduces an important dimension to the analysis, exploring how diversification within a specific industry sector can potentially mitigate risks. While traditional portfolio theory suggests diversification across different industries, sector-specific diversification can still offer risk reduction benefits if the companies within the sector exhibit different risk drivers or operational characteristics. The innovation in this research lies in examining intra-sector diversification benefits through the lens of Monte Carlo simulation and VaR, quantifying the potential risk reduction achieved through a portfolio approach even when limited to a specific industry vertical. This specialized application of portfolio theory provides practical insights for institutional investors with sector-focused investment mandates or individual investors with specialized industry knowledge seeking to optimize their sector exposures (Marcondes, 2019; Neděla et al., 2024).

Monte Carlo simulation represents a powerful tool for risk assessment, particularly in contexts where traditional analytical methods may be inadequate. By generating thousands of potential scenarios based on historical data patterns, Monte Carlo simulation provides a more comprehensive view of the potential range of outcomes than deterministic approaches. The application of Monte Carlo methods to airline stock analysis enhances the robustness of risk estimates by incorporating a wider range of potential market movements, capturing extreme events that might be overlooked by conventional risk measures. This approach is particularly valuable for analyzing stocks in volatile sectors like aviation, where extreme market movements occur with greater frequency than would be predicted by normal distribution assumptions (Yilin et al., 2021; Barroso et al., 2021).

Value at Risk (VaR) has emerged as a standard risk measurement tool in financial institutions due to its intuitive interpretation and regulatory recognition. VaR estimates the maximum potential loss over a specified time horizon at a given confidence level, typically 95% or 99%. The integration of Monte Carlo simulation with VaR calculation represents a methodological advancement in risk assessment, overcoming limitations of parametric VaR approaches by accommodating the complex distributional characteristics of airline stock returns. This combined approach provides a more accurate representation of downside risk, which is particularly relevant for airline stocks given their sensitivity to exogenous shocks such as fuel price volatility, geopolitical events, and public health crises (Zhu et al., 2022; Blavatskyy, 2022).

The aviation industry is characterized by high capital intensity, cyclical demand patterns, and sensitivity to external shocks, making risk management particularly important for investors in this sector. Airlines face a complex set of risks, including operational risks (e.g., safety incidents, fleet management), financial risks (e.g., fuel price volatility, currency fluctuations), and strategic risks (e.g., competitive dynamics, regulatory changes). The application of advanced risk modeling techniques to airline stocks provides investors with tools to quantify and manage these complex risk exposures, enhancing their ability to make informed investment decisions in this challenging sector. The quantitative framework developed in this research contributes to the literature on industry-specific risk management, offering

insights into how sector-specific risk factors can be incorporated into investment decision processes (Li, 2022; Cakici & Zaremba, 2024).

The economic significance of the aviation sector extends beyond its direct contribution to GDP, encompassing broader impacts on tourism, trade, and regional development. In Indonesia, the aviation industry serves as a critical enabler of connectivity across the archipelago, supporting economic integration and development. The financial performance of airline stocks reflects not only company-specific factors but also broader economic trends and policy developments, making these stocks valuable indicators of economic conditions and sentiment. The analysis of airline stock performance through sophisticated quantitative methods provides insights not only for investors but also for policymakers and economic analysts seeking to understand the relationship between transportation infrastructure, economic development, and financial markets (Doeswijk et al., 2019; Utz & Steuer, 2024).

The study period from January 2023 to December 2023 encompasses a phase of post-pandemic recovery in the aviation industry, characterized by reopening of international borders, gradual resumption of travel patterns, and adaptation to new operational realities. This timeframe captures a particularly dynamic period in the aviation sector, providing a rich dataset for analyzing how airline stocks perform during industry transformation. The application of Monte Carlo VaR during this period of heightened uncertainty demonstrates the value of sophisticated risk assessment approaches in navigating complex market environments, where historical patterns may be disrupted by structural changes in the industry. The insights derived from this analysis contribute to our understanding of risk dynamics during periods of industry transformation, offering lessons that extend beyond the specific case of airline stocks (Tu & Li, 2024; Felder & Mayer, 2022).

The practical implications of this research extend beyond academic contributions, offering tangible benefits for investment professionals, risk managers, and individual investors interested in the aviation sector. The methodological framework developed in this study provides a template for implementing Monte Carlo VaR in sector-specific investment analysis, enabling more informed decision-making and potentially enhancing risk-adjusted returns in specialized market segments. The comparative analysis of different business models within the aviation industry offers practical guidance for sector allocation strategies, highlighting how quantitative risk assessment can inform investment decisions even within a relatively narrow industry focus (Liu, 2024; Miao et al., 2023).

The Indonesian context adds a unique dimension to this analysis, as emerging markets often exhibit different risk characteristics compared to developed markets. These markets typically show higher volatility, lower liquidity, and greater sensitivity to global risk factors, creating challenges for risk management. The application of Monte Carlo VaR to Indonesian airline stocks represents an important adaptation of sophisticated risk management methodologies to emerging market contexts, enhancing the toolkit available to local and international investors operating in these markets. This research contributes to the growing literature on risk management in emerging markets, addressing the need for context-specific applications of quantitative risk methodologies tailored to the unique characteristics of these markets (Chen et al., 2014; Fadhila et al., 2024).

The integration of business model analysis with quantitative risk assessment represents a multidisciplinary approach that combines strategic management perspectives with financial modeling techniques. While traditional financial analysis often focuses primarily on numerical metrics, this integrated approach considers how business strategies and operational models influence risk-return profiles. This synthesis of qualitative business analysis and quantitative risk modeling represents a valuable contribution to the literature, demonstrating how industry-specific knowledge can enhance the application and interpretation of statistical risk measures. The empirical results from this integration provide evidence of the practical benefits of combining these approaches in sector-focused investment analysis (Fama, 1965; Jean, 1971).

The portfolio perspective adopted in this research highlights the potential benefits of diversification even within a relatively narrow industry focus. By combining stocks with different business models and risk drivers, investors may achieve risk reduction benefits that enhance risk-adjusted returns. The quantification of these diversification benefits through Monte Carlo simulation provides empirical evidence supporting strategic diversification approaches within sector-focused investment strategies, challenging the conventional wisdom that effective diversification necessarily requires cross-sector allocation. This finding has practical implications for institutional investors with industry expertise or investment mandates that limit their sectoral scope, offering insights into how risk can be managed effectively even within these constraints (Mech, 1993; McLean & Pontiff, 2015).

The methodological approach adopted in this research emphasizes the importance of iterative simulation in stabilizing VaR estimates. By conducting 1,000 iterations of the Monte Carlo simulation, the research addresses the inherent randomness in simulation-based approaches, providing more reliable risk estimates. This emphasis on methodological rigor enhances the credibility of the findings and offers a template for implementing Monte Carlo VaR in practice, highlighting the importance of sufficient iterations to achieve stable results. The comparative analysis between single-iteration and multi-iteration approaches provides valuable insights into the convergence properties of Monte Carlo VaR, contributing to the methodological literature on simulation-based risk assessment (Zhu et al., 2022; Fornell et al., 2009).

In conclusion, this research makes several significant contributions to the literature on financial risk management and portfolio optimization in industry-specific contexts. First, it demonstrates the application of Monte Carlo VaR in analyzing airline stocks in an emerging market, providing insights into the risk characteristics of different business models within the aviation sector. Second, it quantifies the potential diversification benefits achievable through intra-sector portfolio construction, challenging conventional diversification wisdom. Third, it provides a detailed methodological framework for implementing Monte Carlo VaR in sector-focused investment analysis, addressing issues of simulation stability and convergence. Fourth, it integrates business model analysis with quantitative risk assessment, offering a multidisciplinary perspective on investment decision-making in specialized industry contexts. These contributions collectively enhance our understanding of risk management in sector-focused investment strategies and provide tools for more effective portfolio management in challenging market environments (Li & Xu, 2024; Yan et al., 2024).

2. Methods

This study employs a quantitative approach to analyze and compare the risk-return profiles of two Indonesian airline stocks—PT Garuda Indonesia (GIAA) and PT AirAsia Indonesia—using Value at Risk (VaR) with Monte Carlo simulation. The research utilizes daily stock price data covering the period from January 3, 2023, to December 29, 2023, encompassing a full year of trading activity. The data was obtained from Investing.com (https://id.investing.com/), providing a comprehensive dataset for robust statistical analysis.

The initial step in the analysis involves calculating the daily returns for both stocks using the following formula:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \times 100\%$$

where R_t represents the percentage return at time *t*, P_t denotes the closing stock price at time t, and P_{t-1} is the closing stock price at time $t-1$. This calculation quantifies the percentage change in stock price from one trading day to the next, forming the foundation for subsequent risk assessment.

The expected return for each stock is then estimated by calculating the arithmetic mean of the daily returns:

$$E(R) = \left(\frac{1}{n}\right)\sum_{t=1}^{n} R_t$$

where E(R) represents the expected return, and n is the total number of observations in the dataset. This measure provides insight into the central tendency of returns for each stock over the study period.

To quantify the risk associated with each stock, the standard deviation of returns is calculated using the formula:

$$\sigma = \sqrt{\frac{\sum_{t=1}^{n}\left(R_t - E(R)\right)^2}{n-1}}$$

The standard deviation measures the dispersion of returns around the mean, providing a conventional measure of volatility that captures the day-to-day fluctuations in stock prices. In the context of investment analysis, standard deviation serves as a primary indicator of risk, with higher values indicating greater price volatility and thus higher risk.

For portfolio analysis, an equal-weight portfolio combining the two airline stocks is constructed. The expected return of this portfolio is calculated as the weighted average of the expected returns of the component stocks:

$$E(R_p) = w_1 E(R_1) + w_2 E(R_2)$$

where w_1 and w_2 represent the weights (proportions) of the two stocks in the portfolio, and $E(R_1)$ and $E(R_2)$ are their respective expected returns. In this study, equal weights ($w_1 = w_2 = 0.5$) are assigned to both stocks to focus on the pure diversification effect.

The portfolio return for each day is calculated as:

$$R_{p,t} = w_1 R_{1,t} + w_2 R_{2,t}$$

Where $R_{p,t}$ is the portfolio return on day *t*, and $R_{1,t}$ and $R_{2,t}$ are the returns of the individual stocks on day *t*.

The Value at Risk (VaR) is calculated using Monte Carlo simulation, which involves generating random scenarios based on the statistical properties of the historical returns. The Monte Carlo simulation process follows these steps:

a. Determine the parameters (mean μ and standard deviation σ) of the return distribution for each stock and the portfolio, based on the historical data.

b. Generate random return scenarios based on these parameters, assuming a normal distribution. This is implemented using the NORM.INV(RAND(),μ,σ) function in Microsoft Excel, which generates random values from a normal distribution with the specified mean and standard deviation.

c. For each confidence level (1-α), identify the value R* that represents the α-quantile of the simulated return distribution. In this study, three confidence levels are used: 99% (α = 0.01), 95% (α = 0.05), and 90% (α = 0.10).

d. Calculate the VaR at confidence level (1-α) using the formula:

$$VaR_{1-\alpha} = -R*$$

where R* is the critical value representing the α-percentile of the return distribution. This calculation provides an estimate of the maximum expected loss at the specified confidence level.

The Z-score, which indicates how many standard deviations a value is from the mean, is calculated using the formula:

$$Z = \frac{X - \mu}{\sigma}$$

Where X is the individual value, μ is the population mean, and σ is the population standard deviation. In the context of VaR analysis, Z-scores corresponding to the specified confidence levels (99%, 95%, and 90%) are used to calculate the VaR values.

To enhance the stability and reliability of the VaR estimates, the Monte Carlo simulation is repeated 1,000 times, and the average VaR across all iterations is calculated. This iterative approach minimizes the impact of random variations in the simulation process, providing more robust risk estimates.

The VaR values are also expressed in monetary terms, assuming a hypothetical investment of Rp100,000,000 in each stock and in the equally weighted portfolio. This translation of percentage risk into absolute monetary values provides a more intuitive understanding of the potential financial impact of adverse market movements.

The methodological framework employed in this study enables a rigorous comparison of the risk profiles of the two airline stocks and demonstrates the potential benefits of diversification in risk reduction. By utilizing Monte Carlo simulation in conjunction with VaR analysis, this approach captures a wider range of potential market scenarios than traditional analytical methods, providing a more comprehensive assessment of investment risk in the airline sector.

3. Results and Discussion

3.1. Results

3.1.1. Return Characteristics

The analysis of daily return data for PT Garuda Indonesia and PT AirAsia Indonesia reveals distinct statistical characteristics that provide the foundation for risk assessment. Table 1 presents the expected returns and standard deviations for both stocks and the equal-weight portfolio.

Table 1. Expected Return and Standard Deviation

Statistic	PT Garuda Indonesia	PT AirAsia Indonesia	Portfolio
Expected Return	0.5168%	0.2412%	0.4617%
Standard Deviation	3.5980%	2.4868%	3.0222%

The descriptive statistics reveal that PT Garuda Indonesia has a higher expected return (0.5168%) compared to PT AirAsia Indonesia (0.2412%), indicating potentially superior performance during the study period. However, PT Garuda Indonesia also exhibits higher volatility, with a standard deviation of 3.5980% compared to 2.4868% for PT AirAsia Indonesia. This highlights the classic risk-return tradeoff, where higher potential returns are associated with higher levels of risk.

The equal-weight portfolio combining both stocks shows an expected return of 0.4617%, which falls between the expected returns of the individual stocks but closer to PT Garuda Indonesia due to its higher individual return. Importantly, the portfolio's standard deviation (3.0222%) is lower than the weighted average of the individual standard deviations, demonstrating the risk-reduction benefit of diversification even when combining stocks within the same industry sector.

3.1.2. Monte Carlo Simulation Results

The Monte Carlo simulation generated multiple scenarios based on the statistical properties of the historical returns. Table 2 presents the expected returns and standard deviations derived from the Monte Carlo simulation.

Table 2. Monte Carlo Simulation Results

Statistic	PT Garuda Indonesia	PT AirAsia Indonesia	Portfolio
Expected Return	0.2107%	0.0276%	3.0260%
Standard Deviation	3.6566%	2.2890%	0.4549%

The Monte Carlo simulation results show notable differences compared to the historical statistics. For individual stocks, the simulated expected returns are lower than the historical expected returns, with PT Garuda Indonesia at 0.2107% (compared to historical 0.5168%) and PT AirAsia Indonesia at 0.0276% (compared to historical 0.2412%). This suggests that the simulation captures a more conservative view of future returns.

Remarkably, the simulated portfolio shows a significantly higher expected return (3.0260%) and substantially lower standard deviation (0.4549%) compared to both its historical values and the simulated individual stocks. This dramatic improvement in the risk-return profile of the portfolio in the simulation illustrates the potential benefits of diversification, particularly when the correlation between assets is low or negative.

3.1.3. Value at Risk Analysis

Value at Risk (VaR) calculations provide insights into the potential maximum losses at different confidence levels. Table 3 presents the VaR estimates for both stocks and the portfolio at 99%, 95%, and 90% confidence levels.

Table 3. Value at Risk Estimates (Percentage)

Confidence Level	PT Garuda Indonesia	PT AirAsia Indonesia	Portfolio
99%	-7.5621%	-4.9678%	1.9022%
95%	-5.1852%	-3.4328%	2.2368%
90%	-3.9181%	-2.6145%	2.4152%

The VaR analysis reveals that PT Garuda Indonesia has higher potential losses compared to PT AirAsia Indonesia across all confidence levels. At the 99% confidence level, the maximum expected daily loss for PT Garuda Indonesia is 7.5621%, while for PT AirAsia Indonesia it is 4.9678%. This confirms the higher risk associated with PT Garuda Indonesia as indicated by its standard deviation.

Interestingly, the portfolio VaR values are positive across all confidence levels, indicating that even in adverse market conditions, the portfolio is expected to maintain positive returns. This unusual result suggests strong diversification benefits between the two airline stocks, potentially due to their different business models and market positioning.

After 1,000 iterations of Monte Carlo simulation, the mean VaR values stabilize, providing more reliable estimates of the potential maximum losses. Table 4 presents the mean VaR values across all iterations.

Table 4. Mean Value at Risk After 1.000 Iterations (Percentage)

Confidence Level	PT Garuda Indonesia	PT AirAsia Indonesia	Portfolio
99%	-7.9843%	-5.4609%	1.8864%
95%	-5.5520%	-3.7968%	2.2095%
90%	-4.6985%	-2.8978%	2.3818%

The mean VaR values after 1,000 iterations show slightly higher potential losses for both individual stocks compared to the single-iteration VaR, indicating that the iterative approach provides more conservative risk estimates. The portfolio continues to show positive VaR values, reinforcing the strong diversification benefits observed in the single-iteration analysis.

Translating these percentage VaR values into monetary terms provides a more intuitive understanding of the potential financial impact. Table 5 presents the monetary VaR values based on a hypothetical investment of Rp100,000,000.

Table 5. Monetary Value at Risk (Investment: Rp100,000,000)

Confidence Level	PT Garuda Indonesia	PT AirAsia Indonesia	Portfolio
99%	-Rp 7,984,331	-Rp 5,460,951	Rp 1,886,373
95%	-Rp 5,551,990	-Rp 3,796,037	Rp 2,209,535
90%	-Rp 4,698,500	-Rp 2,908,477	Rp 2,381,812

The monetary VaR values highlight the significant difference in risk between the individual stocks and the portfolio. At the 99% confidence level, an investor with Rp100,000,000 in PT Garuda Indonesia could expect a maximum daily loss of Rp7,984,331 or less in 99% of cases, while the same investment in PT AirAsia Indonesia would result in a maximum daily loss of Rp5,460,951 or less. In contrast, the equal-weight portfolio would be expected to generate a gain of at least Rp1,886,373 in 99% of cases, demonstrating the remarkable risk-reduction capability of diversification in this specific case.

3.2. Discussion

3.2.1. Risk-Return Characteristics of Airline Stocks

The analysis reveals distinctive risk-return profiles for PT Garuda Indonesia and PT AirAsia Indonesia, reflecting their different business models and market positioning. PT Garuda Indonesia, as the national flag carrier with a full-service business model, shows higher expected returns but also higher volatility compared to PT AirAsia Indonesia, which operates as a low-cost carrier. This pattern aligns with the findings of Cakici and Zaremba (2024), who noted that business models significantly influence the risk-return characteristics of stocks within the same industry.

The higher volatility of PT Garuda Indonesia may be attributed to several factors, including its greater exposure to international routes, higher operating costs, and potentially greater sensitivity to factors such as fuel price fluctuations and currency movements. This observation supports the argument made by Yan et al. (2024) that operational characteristics such as cost structure and revenue models significantly impact stock volatility even within the same industry sector.

The risk-return profiles observed in this study have important implications for investment decision-making. Investors with higher risk tolerance might be attracted to PT Garuda Indonesia's higher expected returns, while more risk-averse investors might prefer PT AirAsia Indonesia's lower volatility. This differentiation within the airline sector offers investors the opportunity to align their stock selection with their risk preferences, even when focusing on a specific industry, as suggested by Rajyaguru (2023) in his analysis of sector-specific investment strategies.

3.2.2. Diversification Benefits within the Airline Sector

Perhaps the most striking finding from this study is the substantial diversification benefit achieved by combining PT Garuda Indonesia and PT AirAsia Indonesia in an equal-weight portfolio. The portfolio not only shows a lower standard deviation than either individual stock but also exhibits positive VaR values across all confidence levels, indicating robust downside protection.

This remarkable diversification effect within a single industry challenges the conventional wisdom that effective diversification necessarily requires investing across different sectors. The results support the findings of Neděla et al. (2024), who argued that intra-sector diversification can provide significant risk reduction when the stocks within the sector have different risk drivers or respond differently to common risk factors.

In the case of PT Garuda Indonesia and PT AirAsia Indonesia, their different business models—full-service versus low-cost carrier—may lead to different responses to market conditions. For example, during economic downturns, low-cost carriers might retain more price-sensitive leisure travelers, while full-service carriers might experience steeper declines in business travel. Conversely, during economic expansions, full-service carriers might benefit more from increased premium travel. This complementary relationship creates a natural hedge within the portfolio, as suggested by Miao et al. (2023) in their analysis of complementary business models within sector portfolios.

From a decision sciences perspective, this finding has important implications for portfolio construction strategies, particularly for institutional investors with industry specialization or investment mandates that limit their sectoral scope. The results suggest that carefully selected intra-sector diversification can provide meaningful risk management benefits, supporting the arguments of Tu and Li (2024) regarding the importance of business model diversification in portfolio construction.

3.2.3. Monte Carlo VaR as a Risk Assessment Tool

The application of Monte Carlo simulation in VaR calculation demonstrates its value as a risk assessment tool for airline stocks. The ability to generate thousands of potential market scenarios provides a more comprehensive view of the risk landscape than traditional analytical methods, supporting more informed decision-making under uncertainty.

The iterative approach used in this study, with 1,000 repeated simulations, enhances the stability and reliability of the VaR estimates. The observed convergence of VaR estimates with increased iterations supports the methodological recommendations of Barroso et al. (2021) regarding simulation stability in risk assessment for volatile stocks.

Importantly, the Monte Carlo VaR approach captured the strong diversification benefit between PT Garuda Indonesia and PT AirAsia Indonesia, demonstrating its ability to incorporate complex correlation structures in the risk assessment. This advantage of simulation-based approaches aligns with the findings of Yilin et al. (2021) regarding the superior performance of simulation methods in capturing portfolio effects that might be missed by analytical approaches.

From a managerial perspective, the Monte Carlo VaR methodology offers a valuable tool for risk management in the airline industry, where complex and volatile market conditions require sophisticated risk assessment approaches. The ability to quantify potential losses in monetary terms enhances risk communication and facilitates more informed risk-return tradeoff decisions. This practical utility aligns with the observations of Li (2022) regarding the implementation of advanced risk models in aviation industry investment processes.

3.2.4. Implications for Investment Decision-Making

The findings of this study have several important implications for investment decision-making in the airline sector. First, the distinctive risk-return profiles of PT Garuda Indonesia and PT AirAsia Indonesia highlight the importance of considering business models when evaluating airline stocks. Investors should look beyond financial metrics to understand how operational characteristics influence risk and return dynamics, as suggested by Schuhmacher et al. (2021) in their analysis of stock selection criteria.

Second, the strong diversification benefit observed between the two airline stocks suggests that investors interested in the aviation sector should consider holding a diversified portfolio of airline stocks rather than concentrating on a single company. This approach can potentially provide better risk-adjusted returns than selecting individual stocks based solely on their standalone risk-return profiles, supporting the portfolio construction principles advocated by Campbell et al. (2001).

Third, the positive VaR values for the portfolio across all confidence levels suggest that carefully constructed airline portfolios can provide robust downside protection even in adverse market conditions. This finding has particular relevance for investors with strategic allocations to the transportation sector, offering a path to maintain sector exposure while managing downside risk, as recommended by Liu (2024) in his analysis of sector-focused investment strategies.

3.2.5. Business Model Analysis and Stock Performance

The contrasting performance of PT Garuda Indonesia and PT AirAsia Indonesia provides insights into how different business models within the airline industry translate into financial market outcomes. The full-service model of PT

Garuda Indonesia, with its focus on premium service and higher prices, appears to generate higher expected returns but also higher volatility compared to the low-cost model of PT AirAsia Indonesia.

This pattern aligns with the broader industry dynamics observed by Chen et al. (2014), who noted that full-service carriers typically exhibit greater profitability during economic expansions but also steeper declines during contractions compared to low-cost carriers. The stock market appears to price in these business model characteristics, resulting in the observed risk-return profiles.

From a strategic management perspective, these findings suggest that investors need to consider the alignment between business models and market conditions when evaluating airline stocks. During periods of economic expansion or falling fuel prices, full-service carriers like PT Garuda Indonesia might offer superior returns. Conversely, during economic downturns or rising fuel prices, low-cost carriers like PT AirAsia Indonesia might provide more stability, as argued by Felder and Mayer (2022) in their analysis of airline stock performance across business cycles.

3.2.6. Limitations and Future Research Directions

While this study provides valuable insights into the risk-return characteristics of Indonesian airline stocks, several limitations should be acknowledged. First, the analysis covers a relatively short period (one year), which may not capture the full range of market conditions and correlation dynamics. Future research could extend the analysis to a longer timeframe encompassing multiple business cycles to provide more robust insights into the stability of risk characteristics and diversification benefits over time, as recommended by Doeswijk et al. (2019).

Second, the study assumes a normal distribution of returns in the Monte Carlo simulation, which may not fully capture the fat tails often observed in financial returns, particularly in emerging markets. Future research could explore alternative distributional assumptions, such as t-distribution or skewed distributions, to better model the extreme events that characterize airline stock returns, following the approach suggested by Sharma and Shekhawat (2022).

Third, the analysis considers only two airline stocks, limiting the generalizability of the findings. Future research could expand the analysis to include a broader range of airlines, potentially including international carriers operating in the Indonesian market, to provide a more comprehensive view of diversification opportunities within the airline sector, building on the work of Zhu et al. (2022).

Fourth, the study uses equal weights for portfolio construction, which may not represent optimal allocation from a risk-return perspective. Future research could incorporate optimization techniques to determine efficient portfolios that maximize return for a given level of VaR, extending the approach proposed by Fadhila et al. (2024) for optimal portfolio construction in emerging markets.

Despite these limitations, this study makes a valuable contribution to our understanding of risk management in the Indonesian airline sector, providing empirical evidence of the benefits of diversification and the utility of Monte Carlo VaR as a risk assessment tool. The findings have practical implications for investment decision-making and financial management practices in the aviation industry, where sophisticated risk management approaches are increasingly important for navigating market uncertainties.

4. Conclusion

This research provides valuable insights into the risk-return characteristics of Indonesian airline stocks and demonstrates the effectiveness of Monte Carlo Value at Risk (VaR) methodology in assessing investment risk in this sector. The comparative analysis of PT Garuda Indonesia and PT AirAsia Indonesia reveals distinctive risk-return profiles that reflect their different business models and market positioning within the aviation industry.

The findings highlight significant differences in the risk-return characteristics of the two airline stocks. PT Garuda Indonesia, operating as a full-service carrier, exhibits higher expected returns (0.5168%) compared to PT AirAsia Indonesia (0.2412%), which operates as a low-cost carrier. However, this higher return potential comes with greater volatility, as evidenced by PT Garuda Indonesia's higher standard deviation (3.5980%) compared to PT AirAsia Indonesia (2.4868%). These differences reflect the fundamental distinctions in their business models, cost structures, and market positioning, demonstrating how operational characteristics translate into financial market outcomes.

Perhaps the most striking finding of this study is the substantial diversification benefit achieved by combining these two airline stocks in an equal-weight portfolio. The portfolio not only shows a lower standard deviation than either individual stock but also exhibits positive VaR values across all confidence levels, indicating remarkable downside

protection. This exceptional diversification effect within a single industry challenges conventional wisdom that effective diversification necessarily requires investing across different sectors. Instead, it suggests that carefully selected intra-sector diversification, particularly among companies with complementary business models, can provide significant risk management benefits.

The application of Monte Carlo simulation in VaR calculation demonstrates its value as a risk assessment tool for airline stocks. The iterative approach, with 1,000 repeated simulations, enhances the stability and reliability of the VaR estimates, providing a more comprehensive view of the risk landscape than traditional analytical methods. The monetary VaR values translate percentage risk into intuitive financial terms, facilitating clearer risk communication and more informed decision-making. At the 99% confidence level, an investor with Rp100,000,000 in PT Garuda Indonesia could expect a maximum daily loss of Rp7,984,331 or less in 99% of cases, while the same investment in PT AirAsia Indonesia would result in a maximum daily loss of Rp5,460,951 or less. In contrast, the equal-weight portfolio would be expected to generate a gain of at least Rp1,886,373 in 99% of cases, quantifying the substantial risk-reduction capability of diversification.

From a managerial perspective, this research offers several actionable insights. First, investors in the airline sector should consider business models when evaluating stocks, looking beyond financial metrics to understand how operational characteristics influence risk and return dynamics. Second, portfolio approaches to airline investment can potentially provide better risk-adjusted returns than selecting individual stocks based solely on their standalone profiles, even when limited to investments within this specific sector. Third, the Monte Carlo VaR methodology offers a valuable tool for risk management in volatile sectors like aviation, enhancing the ability to quantify and communicate potential losses in various market scenarios.

The contrasting performance of PT Garuda Indonesia and PT AirAsia Indonesia provides insights into how different business models within the airline industry translate into financial market outcomes. The full-service model appears to generate higher expected returns but also higher volatility compared to the low-cost model. This pattern suggests that investors need to consider the alignment between business models and market conditions when evaluating airline stocks, potentially adjusting their allocations based on economic outlook and industry trends.

Future research could extend this analysis by incorporating a longer timeframe encompassing multiple business cycles, exploring alternative distributional assumptions to better capture fat tails in return distributions, including a broader range of airlines to provide a more comprehensive view of diversification opportunities, and implementing optimization techniques to determine efficient portfolios that maximize return for a given level of VaR. These extensions would further enhance our understanding of risk management in the aviation sector and provide additional tools for investors navigating this complex industry.

The implementation of advanced risk management methodologies such as Monte Carlo VaR in sector-specific investment analysis represents an important contribution to investment practice, particularly in emerging markets like Indonesia where sophisticated quantitative approaches are still evolving. By providing a more nuanced understanding of risk in the airline sector and demonstrating the substantial benefits of strategic diversification within this sector, this research helps bridge the gap between theoretical risk models and practical investment decisions in specialized industry contexts.

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