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Feasibility Analysis of Investing in Single Vessel Ownership Using the Value at Risk Method

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Abstract

The maritime shipping industry plays a crucial role in economic development, particularly for archipelagic countries like Indonesia. However, investments in ship ownership are highly capital-intensive and exposed to volatility, making robust financial risk assessment essential. This study assesses the feasibility of investing in single-vessel ownership, specifically a Medium Range (MR) product tanker within a 16-year time frame, aligned with its remaining economic life, utilizing the Value at Risk (VaR) method in addition with Monte Carlo simulation to account for financial uncertainties. A Discounted Cash Flow (DCF) model assessed base-case feasibility using Net Present Value (NPV), Internal Rate of Return (IRR), and Debt Service Coverage Ratio (DSCR), and under deterministic conditions, the investment showed strong viability with an NPV of USD 13.50 million, IRR of 16.89%, and DSCR of 2.21. To assess risk, 10,000 Monte Carlo simulations were conducted, varying operating costs and dry docking costs at a 95% confidence level. The results demonstrate that even under combined risk scenarios, the project remains feasible, with an NPV at Risk of $12.18 million and an IRR at Risk of 15.47%. The research confirmed resilience under individual cost uncertainties, where modest reductions do not compromise feasibility, thereby demonstrating that MR tanker ownership is financially viable under both deterministic and probabilistic scenarios, and supporting VaR and Monte Carlo as practical tools for risk-informed maritime investment decisions.

Keywords
Maritime investment, Vessel ownership, Discounted Cash Flow, Value at Risk (VaR), Monte Carlo simulation

1. Introduction
The shipping industry plays a vital role in the global economy, ensuring the transportation of goods across continents. For a country like Indonesia, this industry is crucial due to the country's archipelagic nature, which comprises more than 17,000 islands. This geographic positioning possesses both opportunities and challenges for Indonesia's maritime logistics industry. Due to the country's archipelagic nature, adequate sea transportation is essential in bridging these islands to fulfil their goods needs and support economic development (Figure 1).

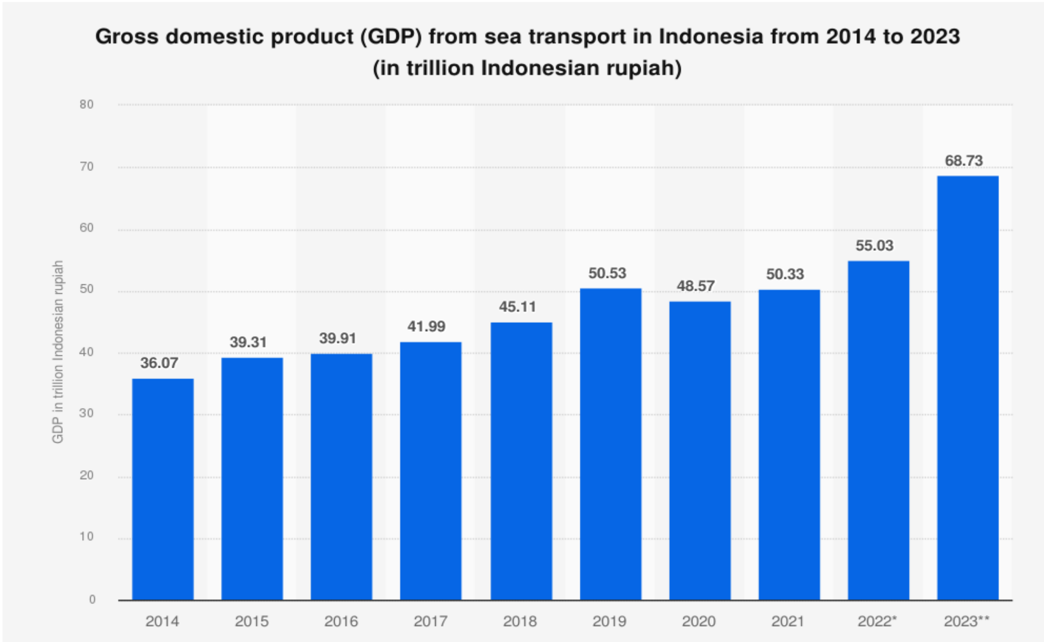


Figure 1. Gross domestic product (GDP) from sea transport in Indonesia from 2014 to 2023 (in trillion Indonesian rupiah)

In 2023 alone, Indonesia's sea transportation industry contributed approximately 68.73 trillion Indonesian rupiah to the nation's gross domestic product (GDP), underscoring the importance of maritime transport activity to the country's economy in generating economic value. A steady increase in GDP from sea transport from 2020 to 2023 highlights the growing demand in the Indonesian sea transport industry (Statista, 2024).

Following the 2008 global financial crisis, the shipping industry began to reassess its approach to investment and risk. One major shift was the growing use of single-ship ownership structures, where a separate legal entity owns each vessel. This arrangement helps lower financial risk by making it easier to manage financing, taxes, or selling the ship later without affecting the whole business. This approach is especially appealing in an industry like shipping, where conditions can change quickly and unpredictably. Freight rates fluctuate, fuel prices are volatile, and vessel values can shift in response to global events, trade patterns, or seasonal demand. These uncertainties make financial planning a real challenge. Población and Serna (2021) highlight that shipping prices are subject to significant stochastic fluctuations, making risk-aware investment appraisal methods indispensable for shipowners and financiers.

Companies can use VaR to understand their risk exposure and employ risk-management techniques to reduce overall financial risk (Alizadeh & Nomikos, 2009). This approach is crucial for shipowners facing financial risks associated with significant investments in new vessels. Economic factors, including GDP growth, inflation, interest rates, significantly impact shipping dynamics, leading to financial challenges (Putri et al., 2024). While prior studies (e.g., Stopford, 2009; Kavussanos & Visvikis, 2016; Población & Serna, 2021) have analyzed shipping investment risks, few have compared ownership models or applied quantitative risk-based frameworks such as Value at Risk (VaR) to single-vessel ownership. This study fills that gap by demonstrating how VaR and Monte Carlo simulation can extend traditional DCF-based feasibility models to a more risk-informed maritime investment framework.

1.1 Objectives

Despite the extensive application of discounted cash flow (DCF) analysis in maritime investment decisions, there remains a notable gap in the integration of probabilistic risk assessment methods, such as Value at Risk (VaR) and Monte Carlo simulation, into project-level evaluations, particularly for single-vessel ownership structures. Existing literature predominantly addresses fleet-level investments or macroeconomic shipping dynamics, often overlooking the unique financial and operational risks encountered by individual vessel owners, especially those operating under single-purpose entities (SPVs). Given the volatility in maintenance costs, there is a growing need for more robust financial frameworks that integrate uncertainty into investment evaluations.

This study seeks to fill that gap by applying an integrated DCF-VaR-Monte Carlo framework to assess the financial feasibility of acquiring a second-hand Medium Range (MR) product tanker with a 16-year remaining operational life. The framework utilizes historical data on freight rates, vessel values, and cost structures to simulate risk-adjusted investment outcomes under both deterministic and probabilistic scenarios. The study provides practical insights into risk management strategies and financial modeling techniques for ship investments. The research aims to support strategic decision-making while also identifying optimal approaches for enhancing profitability, mitigating financial exposure, and maintaining competitive advantage in Indonesia's maritime sector.

2. Literature Review

2.1 Maritime Shipping

Maritime shipping plays a central role in global trade, enabling the transportation of over 80% of world merchandise by volume (Stopford, 2009). The shipping industry plays a key role in global logistics and brings together a wide range of players, including shipowners, charterers, port operators, financial institutions, and regulators, all working within a complex and interconnected system (Figure 2).

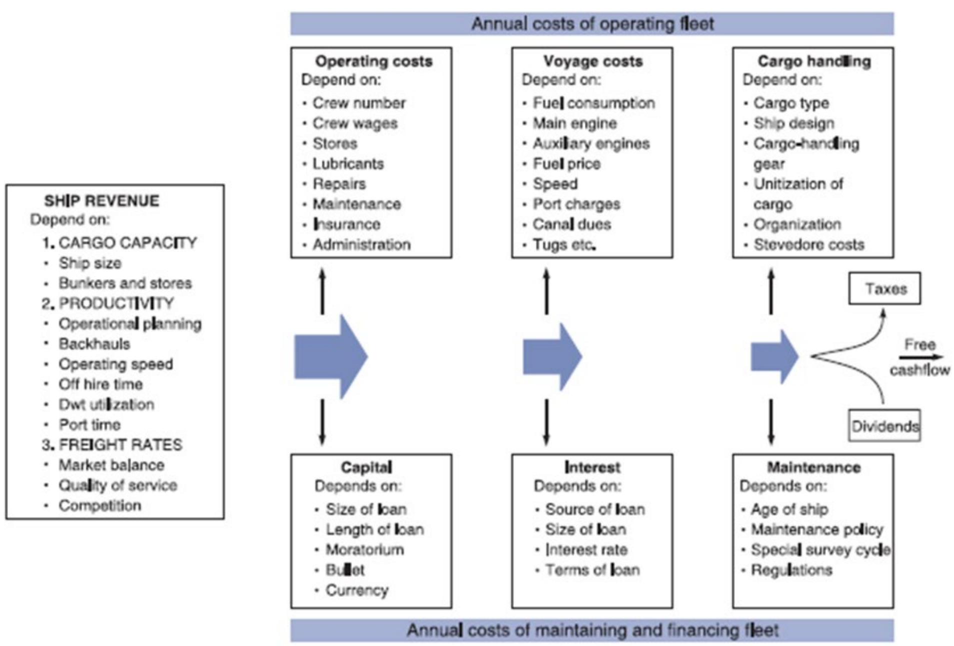


Figure 2. Shipping cash flow model

Vessel ownership investment is one of the fundamental decisions in maritime shipping, which involves the acquisition and management of vessels. Kavussanos and Visvikis (2016) emphasize that ship acquisition decisions involve substantial capital commitments, where the financing structure and cash flow risk directly affect the long-term viability of the investment. From the perspective of a shipowner, the capital expenditure (CAPEX) associated with ship acquisition is the most significant financial commitment. Stopford (2009) explains that CAPEX includes the purchase price of the vessel, financing costs, depreciation, and essential upgrades. These investments are typically justified based on expected freight earnings, the ship's life expectancy, and long-term market projections. Owners engaged in time chartering must ensure that charter hire revenue sufficiently covers both operating expenditure (OPEX) and capital obligations to maintain profitability (Stopford, 2009).

2.2 Value at Risk

Value at Risk (VaR) is defined as the maximum loss that a portfolio is expected to incur over a given time horizon, at a specified confidence level, under normal market conditions (Jorion, 2007). This simple yet powerful measure provides a unified framework for comparing risk across asset classes, business units, and financial institutions. VaR serves as both a measurement and management tool (Jorion, 2007). It can be calculated through several methods, including parametric, historical simulation, and Monte Carlo simulation. Mohanty et al. (2021) highlight that shipping stock returns are characterized by fat tails and skewness, making traditional volatility measures insufficient and reinforcing the need for risk measures such as Value at Risk (VaR) in maritime investment. Abouarghoub and Mariscal (2011) also show that tanker freight returns fluctuate between high- and low-volatility regimes, and propose semi-parametric VaR approaches as robust tools for capturing these dynamics, highlighting the suitability of the approach.

2.3 Discounted Cash Flow (DCF)

DCF calculates the value of an asset by projecting its future cash flows and discounting them using a rate that reflects the risk associated with those cash flows. According to Jorion (2007), DCF is not only pivotal in traditional valuation models but also integrates seamlessly with advanced risk management frameworks, such as Value at Risk (VaR). In this context, DCF is embedded in models used to determine the present value of financial instruments such as bonds and interest rate swaps, where future payments are discounted using zero-coupon yield curves to quantify exposure and volatility (Jorion, 2007). Brealey, Myers, and Allen (2019) emphasize the DCF model's role in optimal capital budgeting, stressing that decisions based on net present value (NPV), a direct application of the DCF model, outperform other heuristic-based approaches. However, the model is sensitive to input assumptions, particularly the discount rate and the estimation of future cash flows, making scenario analysis and risk adjustments essential.

In capital budgeting, three key indicators are widely applied: Net Present Value (NPV), Internal Rate of Return (IRR), and Debt Service Coverage Ratio (DSCR). A project is considered acceptable when the NPV is greater than 0, indicating that it adds value beyond its cost (Brealey, Myers, & Allen, 2019). IRR is the discount rate that sets the NPV of an investment's cash flows to zero. It is commonly used to assess project efficiency, offering a percentage return expected from an investment. Jorion (2007) supports using IRR alongside NPV, especially when evaluating projects under uncertainty. The DSCR is a key financial metric used to assess a borrower's ability to service debt. It is calculated by dividing net operating income by total debt service. A DSCR greater than 1.0 indicates sufficient income to cover debt obligations. DSCR is particularly vital in project finance and loan underwriting. According to Gatti (2013), lenders often require a minimum DSCR threshold (e.g., 1.2 or 1.3) to provide a cushion against unexpected downturns in revenue.

2.4 Monte Carlo Simulation

Monte Carlo simulation involves running a large number of simulations by generating random values for uncertain inputs and observing the distribution of possible outcomes (Glasserman, 2004). In financial risk management, Monte Carlo simulation is often used in pricing derivatives, evaluating investment projects, and calculating Value at Risk (VaR). Jorion (2007) emphasizes the simulation's flexibility in handling portfolios with non-linear instruments such as options. In project valuation, Monte Carlo simulation enhances traditional Discounted Cash Flow (DCF) models by allowing for probabilistic inputs rather than single-point estimates. This leads to a more robust understanding of potential investment outcomes, enabling better decision-making under uncertainty (Mun, 2014).

3. Methods

This study extends established financial evaluation techniques, DCF, VaR, and Monte Carlo simulation, into a unified analytical framework for maritime investment. The novelty of this study lies in integrating DCF, Value at Risk (VaR), and Monte Carlo simulation into a single decision-support framework to evaluate the feasibility of single-vessel ownership under uncertainty. The analysis focuses on a second-hand Medium Range (MR) product tanker with a deadweight of 45,838 DWT and an estimated 16-year remaining economic life. A DCF model, built in Microsoft Excel, is used to calculate Net Present Value (NPV), Internal Rate of Return (IRR), and Debt Service Coverage Ratio (DSCR), using input variables such as capital expenditure, operating costs, and scheduled dry-docking expenses. Revenue is projected based on a daily time-charter rate of USD 14,500 over 355 operational days per year. By combining deterministic projections with probabilistic risk modeling, the study offers a more comprehensive view of investment viability (Figure 3).

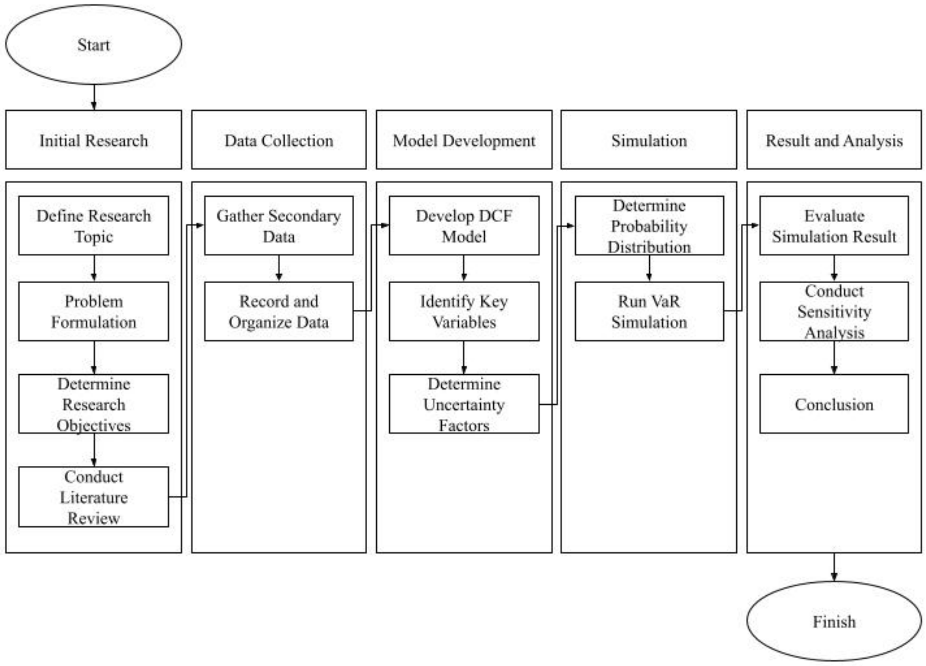


Figure 3. Research Methodology

To capture uncertainty in the analysis, triangular probability distributions were applied to key cost components, specifically repair and maintenance, as well as dry-docking expenses. A Monte Carlo simulation with 10,000 iterations was run at a 95% confidence level using Jupyter Notebook, generating a range of possible outcomes for NPV, IRR, and DSCR. To better understand which factors had the most influence on the results, a sensitivity analysis was also conducted.

4. Data Collection

All data used in this study were obtained from secondary sources and internal industry references. Financial and technical inputs, including vessel acquisition cost, operating expenditure (OPEX), and dry-docking costs, were based on anonymized data shared by a vessel owner operating in the Indonesian tanker market under a time-charter agreement with a major state-linked shipping client. To maintain confidentiality, the company name is not disclosed. To ensure the data used in the analysis was both realistic and consistent, supporting figures were cross-checked against publicly available reports and relevant academic literature. The financial and technical inputs focused on parameters specific to owning a Medium Range (MR) product tanker. Capital expenditure (CAPEX) included the vessel's acquisition cost, while operational expenditure (OPEX) covered typical items such as crew wages, insurance, fuel, maintenance, and administrative costs. Periodic dry-docking expenses were also factored in as a key component of the vessel's lifecycle costs. Revenue projections were based on a fixed daily time-charter rate. These inputs formed the basis of the Discounted Cash Flow (DCF) model and were later used in the Value at Risk (VaR) and Monte Carlo simulations, allowing the financial analysis to reflect real-world conditions in maritime investment.

5. Results and Discussion

5.1 Numerical Results

In the deterministic base case, the investment in an MR product tanker demonstrates strong financial feasibility, with an NPV of USD 13,502,550.73, an IRR of 16.89%, a DSCR Mean of 2.21, and a DSCR Minimum of 1.46.

When incorporating uncertainty through Value at Risk (VaR) and Monte Carlo simulations (10,000 iterations at a 95% confidence level), the financial indicators remain positive, though slightly reduced compared to the base case (Table 1):

Table 1. Risk Analysis Results

Scenario	Risk Type	NPV at Risk	IRR at Risk	Mean DSCR at Risk	Minimum DSCR at Risk
1	Repair and Maintenance Cost	USD 12,761,593.39 (5.48% lower)	16.10% (4.68% lower)	2.14 (3.17% lower)	1.39 (4.79% lower)
2	Dry-docking Cost	USD 12,455,131.63 (7.74% lower)	15.77% 6.62% lower)	2.13 (3.62% lower)	1.19 (18.49% lower)
3	Combined Risk (Repair and Maintenance Cost + Dry-docking cost)	USD 12,183,574.43 (9.77% lower)	15.47% (8.41% lower)	2.10 (4.98% lower)	1.18 (19.18% lower)

Compared to the base case, the combined risk scenario shows a decline of approximately 9.77% in NPV, but remains firmly positive at USD 12,183,574.43. The IRR at risk stands at 15.47%, still well above the cost of capital. At the same time, the minimum DSCR of 1.18 indicates the project retains sufficient capacity to service debt even under unfavorable conditions. Overall, the findings confirm that single vessel ownership of an MR tanker remains financially resilient under both deterministic and probabilistic conditions.

5.2 Graphical Results

The Monte Carlo simulations generated probability distributions for the key financial indicators, NPV, IRR, and DSCR, providing a broader picture of investment performance under uncertainty (Figure 4).

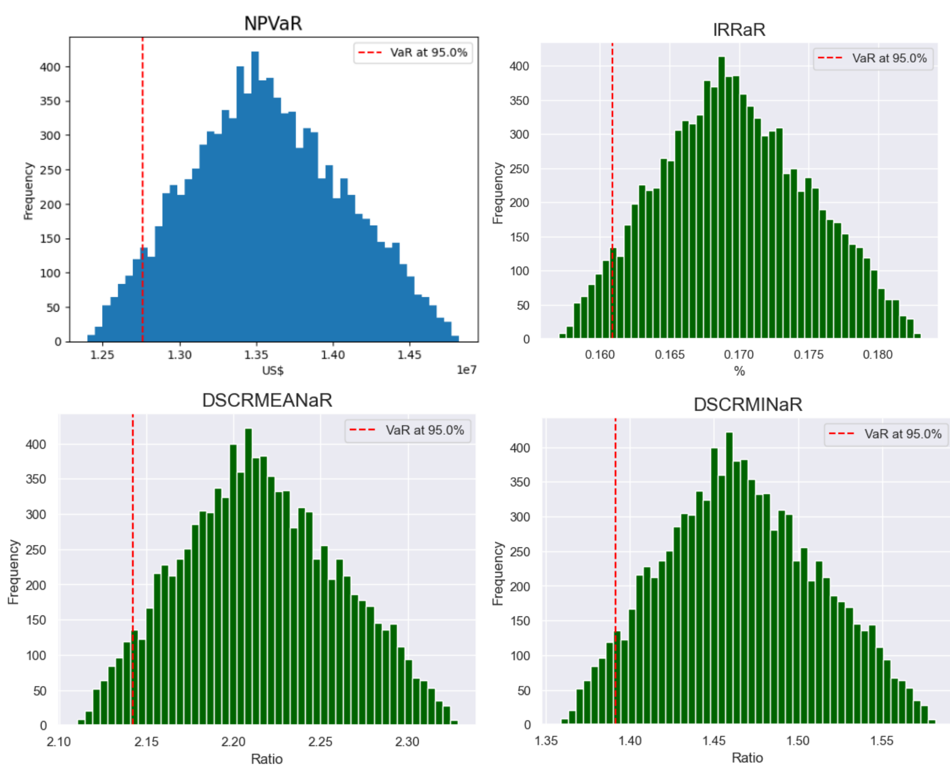


Figure 4. NPV, IRR, and DSCR Mean and DSCR Minimum at Risk of Scenario 1

In scenario 1, with repair and maintenance cost as the risk, the NPV distribution centers around USD 12.76 million, with an IRR of approximately 16.1%. The DSCR distribution averages 2.14, with a minimum of roughly 1.39, providing a more substantial buffer compared to other scenarios. All results indicate that the project remains feasible despite the risk of repair and maintenance costs (Figure 5).

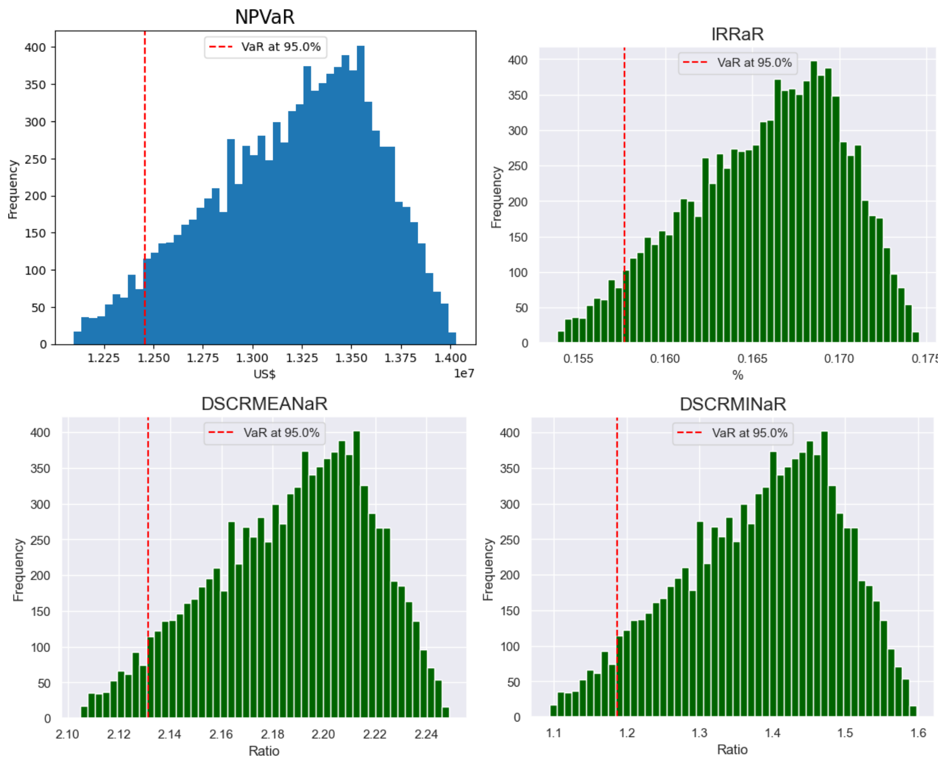
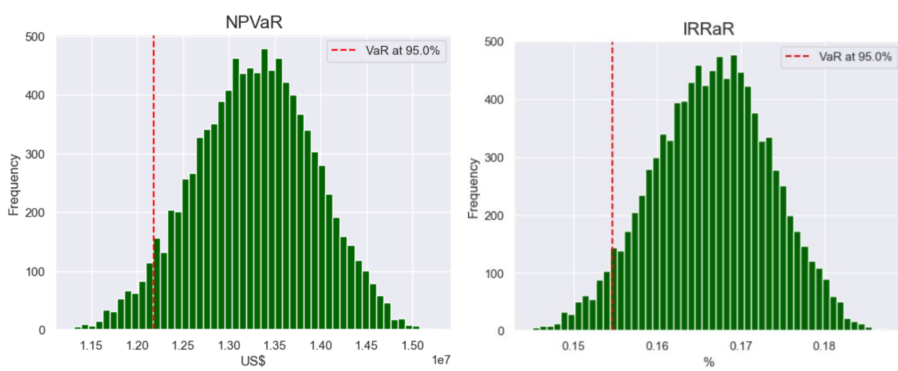


Figure 5. NPV, IRR, and DSCR Mean and DSCR Minimum at Risk of Scenario 2

In scenario 2, where dry-docking costs are the sole source of risk, the NPV distribution shifts to USD 12.45 million. The IRR stabilizes at around 15.8%, while the DSCR averages 2.13, with a minimum of 1.19. Given the periodic nature of dry-docking, the impact is moderate, and the project remains feasible under this risk scenario (Figure 6).



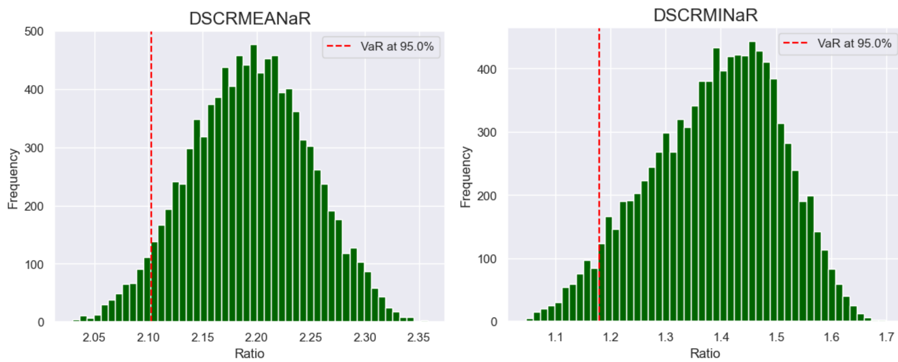


Figure 6. NPV, IRR, and DSCR Mean and DSCR Minimum at Risk of Scenario 3

In the combined risk case, the NPV distribution peaks at USD 12.18 million, while the IRR clusters at around 15.5%. The DSCR distribution shows a mean of 2.10 with a lower bound near 1.18, reflecting tighter margins under adverse conditions but still sufficient to cover debt obligations. The project, therefore, remains financially feasible even under combined risk (Figure 7).

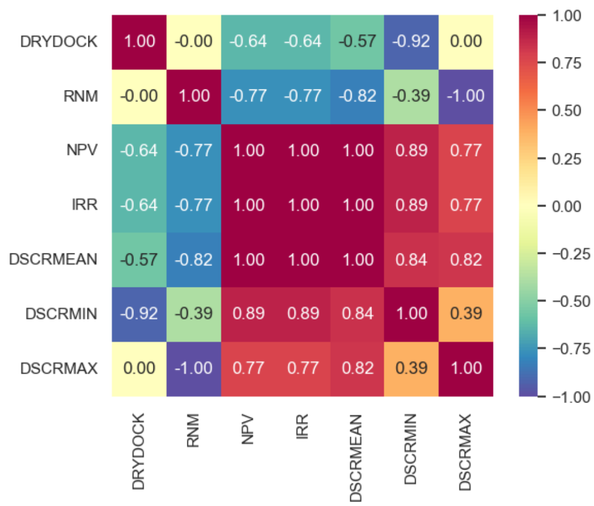


Figure 7. Spearman Correlation

The Spearman correlation heatmap further clarifies the influence of each cost factor. For repair and maintenance cost, the correlations are –0.77 with NPV, –0.77 with IRR, –0.82 with DSCR mean, and –0.39 with DSCR minimum. For dry-docking cost, the correlations are –0.64 with NPV, –0.64 with IRR, –0.57 with DSCR mean, and –0.92 with DSCR minimum. These results confirm that repair and maintenance costs exert the most significant overall influence due to their recurring nature, while dry-docking costs have a powerful effect on the worst-case DSCR outcomes.

5.3 Proposed Improvements

Although the MR tanker investment is financially feasible under all scenarios, the analysis highlights that the minimum DSCR comes close to the critical threshold, reaching 1.18 in the combined risk case. This suggests that debt obligations can still be met, albeit with a relatively narrow margin. The correlation results show that repair and maintenance costs exert the most substantial cumulative influence on financial indicators, such as NPV, IRR, and DSCR mean, while dry-docking costs are more strongly linked to the DSCR minimum, making them critical in shaping the worst-case debt servicing capacity (Table 2).

Table 2. Proposed Improvements

Scenario	Improvement Focus	Cost Adjustment
1	Repair and maintenance cost efficiency	5-10% reduction in repair and maintenance cost
2	Dry-docking optimization	5-10% reduction in dry-docking cost
3	Combined improvements	Joint decrease in repair and maintenance costs and dry-docking costs

Improvement strategies should therefore focus on both areas. For repair and maintenance, measures such as preventive maintenance, digital monitoring, and optimized fuel management can stabilize and reduce recurring costs. For dry-docking, improvements in scheduling, long-term shipyard agreements, and efficiency retrofits during dock periods can help limit cost spikes and strengthen the DSCR margin.

These scenarios underscore that, while the project is already viable, targeted improvements are crucial to enhance financial resilience, particularly to ensure that the DSCR remains safely above minimum thresholds under adverse conditions.

5.4 Validation

The reliability of the model and findings in this study is supported through several complementary measures. First, the analysis employs well-established approaches in financial evaluation, specifically Discounted Cash Flow (DCF) modeling combined with Value at Risk (VaR) analysis, assessed through Monte Carlo simulation. Running 10,000 iterations at a 95% confidence level provides a strong statistical basis, ensuring that a wide range of possible outcomes is captured while minimizing the effect of extreme cases. This aligns with standard practices in assessing high-capital investments.

Assumptions for capital expenditures, operating costs, dry docking, and charter revenues are drawn from credible secondary sources, including industry publications, academic studies, and prior shipping investment research. This ensures that the model inputs are realistic and reflective of actual market conditions in the maritime sector.

The use of Spearman correlation analysis strengthens validation by confirming that the model responds logically to variations in input variables. The results show that repair and maintenance costs have the most significant effect on NPV, IRR, and DSCR mean, while dry-docking costs are more critical for DSCR minimum. This pattern is consistent with financial reasoning, where recurring costs exert sustained pressure and periodic costs shape worst-case debt service capacity.

Furthermore, the findings are in line with previous research in maritime finance, which highlights both the profit potential and risk involved in single-vessel ownership, especially in volatile market conditions. While this study focuses on the Indonesian shipping context, the results reflect trends seen in global maritime investment, adding confidence to the strength and relevance of the analysis.

6. Conclusion

This study sets out to evaluate the financial feasibility and risk profile of owning a single Medium Range (MR) product tanker. The results met all research objectives: the base-case analysis showed strong performance with positive NPV, IRR, and DSCR, while Monte Carlo simulations, run with 10,000 iterations, confirmed the project's resilience under uncertainty. The sensitivity analysis pointed to repair and maintenance costs as the biggest influence on overall financial returns, while dry-docking costs had the strongest impact on the project's ability to meet debt obligations (DSCR minimum). Beyond confirming feasibility, the study also sheds light on where risk management efforts should be focused. By combining Value at Risk (VaR) and Monte Carlo simulation with traditional finance tools, this research offers a more complete picture of financial risk in maritime investment, especially for single-vessel ownership. This approach provides added value for both investors and policymakers in informing risk-based decisions for Indonesia's maritime industry. This study is limited by its reliance on secondary data and focuses on a single vessel type (MR tanker). Future research should expand the scope to compare multiple ownership structures and integrate additional uncertainties such as freight rate volatility, financing mix, and regulatory changes.

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