

Financial Feasibility Analysis and Monte Carlo Risk Assessment of PT Satya Amerta Havenport in the North Morowali Port Development Project

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Abstract: This study aims to analyze the financial feasibility and Monte Carlo risk of PT Satya Amerta Havenport in the North Morowali port development project. The investment analysis methods used include Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Profitability Index (PI), which are part of the capital budgeting method. This study is expected to provide a framework for financial feasibility studies under various scenarios. Through calculations using the NPV, IRR, PP, and PI methods, it is hoped that PT Satya Amerta Havenport can make decisions and analyze whether the invested capital can be recovered according to the predetermined schedule with an acceptable level of risk. This study also evaluates the risks that may be faced during the development process using Monte Carlo sensitivity analysis. Based on the research findings, the researcher concludes that investment development using PP, NPV, IRR, and PI in the North Morowali port development project is feasible. The development of the North Morowali port project, simulated through the Monte Carlo method, demonstrates a high level of investment confidence.

Introduction

Economic growth in eastern Indonesia, particularly in North Morowali Regency, Central Sulawesi, shows enormous potential in the industrial and logistics sectors. This region is recognized as one of the largest nickel-producing areas in Indonesia, so the need for supporting infrastructure such as ports has become increasingly urgent. In supporting the smooth flow of goods and logistics, the presence of a representative and financially feasible port is crucial to driving distribution efficiency and improving regional connectivity. Port development requires very large investment and carries long-term economic and social impacts. Therefore, by conducting a financial feasibility analysis, a company can minimize the risk of loss and ensure that the project being undertaken delivers optimal benefits.

In the context of national infrastructure development, ports play a strategic role in driving local and national economic growth. According to Susanti (2024), financial feasibility analysis is an important step in the investment decision-making process because it provides a picture of whether a project can deliver an adequate return relative to the risks faced. This

analysis considers not only the magnitude of the initial investment, but also cash flow projections, the rate of return on capital, and the investment payback period. Investment is a key determinant of Gross Domestic Product (GDP) at the national level and Gross Regional Domestic Product (GRDP) at the regional level, while also generating a multiplier effect across directly and indirectly related economic sectors and expanding employment, particularly in labor-intensive sectors.

PT Satya Amerta Havenport is a company engaged in port service activities, serving as a supporting facility for the PT Stardust Estate Investment Industrial Estate in North Morowali Regency, Central Sulawesi. As a form of compliance with Presidential Regulation Number 109 of 2020 concerning the acceleration of National Strategic Projects, the company has signed a port construction contract with PT Hillcon Jaya Sakti in July 2022 to carry out port infrastructure development. Based on the project budget calculation, the actual cash flow during 2021-2025 exhibits a typical “J-Curve” pattern of large infrastructure projects: a cash-burning phase (2021-2024) for building and starting operations, followed by a cash-generating phase beginning in 2025.

Based on the operating cash flow data, the company recorded negative operating cash flow from 2021 to 2024, which is reasonable in a large-scale port development project where, in the early years, operational and maintenance costs far exceed incoming revenue because the facilities may not yet be fully operational. A turnaround occurred in 2025, when operating cash flow surged to a positive IDR 61.42 billion, indicating that the port had reached an occupancy or throughput level sufficient to cover its entire operating costs. The investing cash flow shows an increasing trend of expenditure, especially entering 2024 and 2025, reflecting substantial capital expenditure for additional infrastructure such as docks or cranes. Meanwhile, the financing cash flow reveals heavy reliance on external capital between 2022 and 2024 (reaching IDR 300-376 billion per year) before turning negative in 2025 as the company began to repay debt independently.

Because large-scale projects always involve uncertainty in price fluctuations, additional costs, construction risk, and external factors, the application of Monte Carlo risk analysis is highly relevant for projecting possible variations in financial outcomes and measuring the level of risk that may be faced. Hariyanto and Yuliani (2018) state that Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP) are the main indicators most widely used in evaluating project feasibility. NPV shows the difference between the present value of cash inflows and outflows; IRR measures the rate of return on investment; while PP calculates the time required to recover the initial capital. Therefore, the researcher is interested in conducting a study titled “Financial Feasibility Analysis and Monte Carlo Risk Assessment of PT Satya Amerta Havenport in the North Morowali Port Development Project,” which integrates NPV, IRR, PP, and PI with Monte Carlo simulation to provide a more comprehensive picture of financial feasibility criteria and the potential risk of the project.

Investment Management

According to Tandelilin (2024), investment management is the professional process of managing funds to achieve specific financial goals, involving in-depth analysis of various investment instruments such as stocks, bonds, and real assets. In the context of infrastructure development, Fahmi (2023) emphasizes that investment management must be able to synergize the availability of capital with the selection of assets that have high strategic value, given that investments in physical sectors such as ports require large capital with long payback periods. Bodie, Kane, and Marcus (2021) assert that the core of modern investment

management is asset allocation that is adaptive to global market changes, where the success of an investment depends heavily on the investor's understanding of the correlation between market risk and expected return.

Financial Feasibility Analysis

Financial feasibility analysis is a systematic process for evaluating whether an investment project is feasible to undertake based on a comparison between the costs and the expected financial benefits (Sutrisno, 2024; Risal & Aqsa, 2024). The analysis emphasizes the importance of cash flow projections, the rate of return on capital, and the investment payback period, using quantitative methods such as NPV, IRR, and Payback Period. Because investment decisions are always confronted with the dimensions of time and uncertainty, the concept of the Time Value of Money (TVM) becomes the main foundation. According to Brigham and Houston (2022), the value of one currency unit in the future is not the same as its value today because of interest, inflation, and risk; therefore, every future cash flow must be discounted to its present value to be compared equitably with the investment cost incurred today.

Net Present Value (NPV)

According to Susanti (2024), Net Present Value (NPV) is an investment evaluation method used to assess the feasibility of a project by calculating the difference between the present value of all expected future cash inflows and the value of the initial investment. NPV shows how much net profit (in present value) can be obtained from a project after taking into account the cost of capital (discount rate). If the NPV is positive, the project is feasible to undertake because it will add value to the company; conversely, if the NPV is negative, the project is considered infeasible because it will cause a loss. NPV also takes into account the time value of money, meaning that money received today is more valuable than money received in the future.

Internal Rate of Return (IRR)

According to Susanti (2024), the Internal Rate of Return (IRR) is the rate of return on an investment that makes the present value of cash inflows equal to the value of the initial investment, or in other words, the discount rate that makes the Net Present Value (NPV) equal to zero. IRR is an important indicator in investment decision-making because it shows how large a rate of return can be obtained from a project. An IRR greater than the cost of capital indicates that the investment is financially feasible.

Payback Period (PP)

According to Susanti (2024), the Payback Period (PP) is an investment appraisal method used to determine how long it takes to recover the initial investment funds from the net cash flow generated by the project. PP is one of the tools for measuring project risk, because it shows how quickly an investor can recover the capital invested. The shorter the payback period, the smaller the investment risk faced, since the capital is recovered more quickly and the project becomes more flexible to external changes such as inflation, interest rates, or market shifts.

Profitability Index (PI)

According to Ross et al. (2020), the Profitability Index (PI), or benefit-cost ratio, is the ratio between net cash flows. This method suggests that if the PI is greater than 1, the investment plan for the project concerned is sufficiently sound. Compared with NPV, the PI measures the relative increase in the owners' wealth, whereas NPV measures the absolute increase in the owners' wealth. The PI is therefore an important complement to NPV: if NPV measures the increase in wealth in absolute rupiah terms, the PI indicates the efficiency of capital use.

Monte Carlo Risk Analysis

Collier and Evans (2023) explain that Monte Carlo analysis is a technique for representing uncertainty in mathematical models by using random numbers to simulate various possible outcomes of a process, thereby producing a probability distribution of those outcomes. In assessing business feasibility, Monte Carlo analysis is a powerful tool because it allows uncertainty and risk to be taken into account. Rather than using a single estimated value for each variable, Monte Carlo runs a number of varying scenarios to describe the range of possible outcomes, yielding a more realistic distribution of results. The main stages generally include determining the probability distributions of key variables, building cumulative probability distributions, assigning random number intervals, generating random numbers, simulating a series of trials, and analyzing the results to obtain an overall picture of the possible outcomes and their probabilities.

Research Method

This study employs a mixed-methods approach that combines quantitative and qualitative analysis within a single study to obtain more comprehensive, valid, reliable, and objective data (Creswell, 2015; Sugiyono, 2016). The quantitative approach is used to calculate the financial feasibility of the project using NPV, IRR, Payback Period, and Profitability Index, as well as to simulate risk using the Monte Carlo method in order to capture the range of possible outcomes arising from uncertainty. The qualitative approach is used to understand non-financial factors such as the socio-economic conditions of the community, government policy, and the views of stakeholders related to port development. By combining the two, the study not only presents financial results and risk numerically but also provides comprehensive insight into the acceptability, challenges, and social implications of the project.

The research was conducted at PT Satya Amerta Havenport, a company engaged in the nickel industry that is building a port in North Morowali as a nickel-industry hub in Central Sulawesi. The research design includes several studies: a theoretical review of theories relevant to the implementation of feasibility investment; an empirical review analyzing the assumptions used in feasibility documents; a feasibility study estimating investment feasibility based on risk and return analysis, calculating the project's cash flow projections using inputs such as investment cost plans, revenue, and operational costs, and performing calculations of NPV, IRR, PI, and PP; and a risk study conducting an investment risk analysis based on the Value at Risk Monte Carlo method or normal variance.

Data collection techniques utilize a combination of documentation, observation, and literature study. Documentation is used to collect secondary data in the form of project planning documents, projected financial statements, cost budgets, and cash flow estimates, which become the main material for the financial feasibility calculations. Observation is used to directly assess geographic conditions, accessibility, and existing port infrastructure in order

to identify potential field constraints. The data period used is actual data for 2021-2025 with financial projections for 2026-2030. Several operational definitions of the variables used to assess investment feasibility are summarized below.

Net Present Value (NPV) is a more advanced capital budgeting technique calculated as the difference between the gross present value of discounted net cash inflows and the initial investment; a project is acceptable when $NPV \geq 0$. Internal Rate of Return (IRR) is the discount rate, expressed as a percentage, that makes the present value of the project's net cash flows equal to the present value of its investment, that is, the rate that makes the NPV equal to zero. Payback Period (PP) is the method used to calculate the length of time required to recover the invested funds from the annual net cash inflows generated by the investment; the shorter the period, the smaller the uncertainty risk. Profitability Index (PI), or benefit-cost ratio, is the ratio between the gross present value and the investment outlays, where a PI greater than 1 indicates a sound investment. Investment risk with Monte Carlo simulation uses repeated random sampling to estimate the outcome of uncertain events, generating a probability distribution of NPV characterized by its mean and standard deviation.

Result and Discussion

General Overview of the Research Object

PT Satya Amerta Havenport (SAH) is a strategic Port Business Entity focused on providing integrated port services in North Morowali, Central Sulawesi. As the main logistics gateway for the mining and mineral downstream industry, the company plays a crucial role in supporting the smoothness of the national supply chain, particularly in the distribution of nickel and coal commodities. The company's vision is to become a leading port operator in eastern Indonesia that prioritizes operational efficiency without neglecting environmental sustainability. The services offered span a broad spectrum, from providing docks for large-capacity vessels and navigation pilotage to extensive stockpile facilities for bulk cargo, supported by modern mechanical equipment and competent human resources, while meeting international maritime compliance standards, including occupational safety (K3) and port facility security (the ISPS Code).

Analysis of Research Results

Over the five-year period, the actual cash flow of PT Satya Amerta Havenport from 2021 to 2025 reflects an intensive infrastructure development phase, in which operating cash flow was consistently negative from 2021 to 2024, with the deepest decline in 2023 reaching -IDR 48.99 billion. The company achieved a significant performance reversal in 2025, with operating cash flow recording a positive value of IDR 61.42 billion. The operational funding shortfall in the early years was fully supported by very large financing cash flows, ranging from IDR 300 billion to IDR 376 billion per year from 2022 to 2024. Net cash flow remained positive from 2021 to 2024 thanks to strong external funding before finally recording a negative value of -IDR 112.94 billion in 2025 as the funding portion was reduced and physical investment increased. For the 2026-2030 projection, operating cash flow is assumed to grow by 30% per year (aggressive scenario), investing cash flow remains negative due to maintenance and capacity-development needs, and financing cash flow remains negative as the company focuses on repaying long-term debt.

Table 1. Actual Cash Flow (2021-2025) and Projected Cash Flow (2026-2030, Aggressive Growth 30% per Year)

Cash Flow Category	2021	2022	2023	2024	2025
Operating Activities	-30,100,929,706	-36,233,742,565	-48,995,274,024	-15,930,976,041	61,421,176,130
Investing Activities	90,003	4,905,985,931	-732,797,723	-8,504,843,784	-40,886,868,268
Financing Activities	30,742,825,708	343,172,880,046	376,968,211,201	300,668,161,142	-133,479,616,447
Net Cash Flow	641,986,005	311,845,123,411	327,240,139,455	276,232,341,317	-112,945,308,585
Cash Flow Category	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)
Operating Activities	79,847,528,968	103,801,787,659	134,942,323,957	175,425,021,144	228,052,527,487
Investing Activities	-45,000,000,000	-50,000,000,000	-55,000,000,000	-60,000,000,000	-65,000,000,000
Financing Activities	-150,000,000,000	-120,000,000,000	-100,000,000,000	-80,000,000,000	-50,000,000,000
Net Cash Flow	-115,152,471,032	-66,198,212,341	-20,057,676,043	35,425,021,144	113,052,527,487

If “capital” is interpreted as the money spent to acquire assets (port construction), the identified investment embedded up to 2025 is summarized below.

Table 2. Value of Fixed-Asset Investment (Capital Expenditure)

Year	Fixed-Asset Purchase (IDR)
2021	(Not significant)
2022	(Net positive investment, IDR 4.9 B)
2023	732,797,722
2024	8,504,843,783
2025	40,886,868,267
Total Identified Investment	50,124,509,772

Aggressive Projection of NPV, IRR, PP, and PI (Cash Flow 2026-2030 up 30% per Year)

Net Present Value is a higher-level capital budgeting technique that subtracts the initial investment from the present value of discounted cash inflows and outflows. The detailed calculation is presented below.

Table 3. Net Present Value (Projected Cash Flow 2026-2030 up 30% per Year)

Year	Net Cash Flow (IDR)	Discount Factor (10%)	Present Value (PV)
2021 (A)	641,986,005.42	0.9091	583,621,825
2022 (A)	311,845,123,411.30	0.8264	257,721,216,533
2023 (A)	327,240,139,454.55	0.7513	245,861,571,492
2024 (A)	276,232,341,316.98	0.6830	188,670,324,930
2025 (A)	-112,945,308,584.61	0.6209	-70,129,507,031
2026 (P)	-115,152,471,032.00	0.5645	-65,000,124,733
2027 (P)	-66,198,212,341.00	0.5132	-33,968,121,785
2028 (P)	-20,057,676,043.00	0.4665	-9,357,062,246
2029 (P)	35,425,021,144.00	0.4241	15,023,639,400
2030 (P)	113,052,527,487.00	0.3855	43,586,829,471
NPV			732,992,387,856

Table 4. NPV, IRR, PP, and PI (Cash Flow 2026-2030 up 30% per Year)

Indicator	Result	Benchmark	Description
NPV	IDR 732,992,387,856	> 0	Feasible
IRR	18.45%	> DF 10%	Feasible
PI	1.38	> 1.00	Feasible
PP	Year 2022 (Cumulative Cash)	< Projection Period	Feasible

The NPV of IDR 732.99 billion indicates that the project delivers very significant added value above the 10% cost of capital over the ten-year horizon. With an IRR of 18.45%, the investment can withstand interest-rate increases up to that threshold before reaching the break-even point. The PI of 1.38 means that every IDR 1,000,000 invested yields a present value of IDR 1,380,000, while capital is recovered very quickly (in 2022) thanks to the large injection of bank financing and equity at the start of the operational period.

Moderate Projection of NPV, IRR, PP, and PI (Cash Flow 2026-2030 up 10% per Year)

Table 5. Net Present Value (Projected Cash Flow 2026-2030 up 10% per Year)

Year	Net Cash Flow (IDR)	Discount Factor (10%)	Present Value (PV)
2021 (A)	641,986,005	0.9091	583,629,477
2022 (A)	311,845,123,411	0.8264	257,708,810,003
2023 (A)	327,240,139,455	0.7513	245,855,516,773
2024 (A)	276,232,341,317	0.6830	188,666,689,120
2025 (A)	-112,945,308,585	0.6209	-70,127,742,100
2026 (P)	-124,239,839,444	0.5645	-70,133,389,366
2027 (P)	-136,663,823,388	0.5132	-70,135,874,163
2028 (P)	-150,330,205,727	0.4665	-70,129,041,000
2029 (P)	-165,363,226,299	0.4241	-70,130,544,270
2030 (P)	-181,899,548,929	0.3855	-70,122,276,110
NPV			362,035,778,364

Table 6. NPV, IRR, PP, and PI (Cash Flow 2026-2030 up 10% per Year)

Indicator	Result	Benchmark	Description
NPV	IDR 362,035,778,364	> 0	Feasible
IRR	42.80%	> DF 10%	Highly Feasible
PI	1.52	> 1	Feasible
PP	~1 Year (2021-2022)	< Projection Period	Highly Feasible

With a positive value of IDR 362 billion, the project adds to the company's wealth in absolute terms. Although there are negative cash flows in the later years (2025-2030), the large surplus in 2022-2024 is more than sufficient to cover that burden after adjusting for the time value of money. The IRR of 42.80% reflects a very high rate of return, providing a wide safety cushion against economic risk, while the PI of 1.52 indicates that every IDR 1,000 spent returns a present value of IDR 1,520, confirming the efficiency of the investment.

Pessimistic Projection of NPV, IRR, PP, and PI (Cash Flow 2026-2030 down 20% per Year)

Table 7. Net Present Value (Projected Cash Flow 2026-2030 down 20% per Year)

Year	Net Cash Flow (IDR)	Discount Factor (10%)	Present Value (PV)
2021 (A)	641,986,005.42	0.9091	583,621,825
2022 (A)	311,845,123,411.30	0.8264	257,721,216,533
2023 (A)	327,240,139,454.55	0.7513	245,861,571,492
2024 (A)	276,232,341,316.98	0.6830	188,670,324,930
2025 (A)	-112,945,308,584.61	0.6209	-70,129,507,031

Year	Net Cash Flow (IDR)	Discount Factor (10%)	Present Value (PV)
2026 (P)	-131,121,976,826.00	0.5645	-74,018,355,918
2027 (P)	-86,958,569,873.00	0.5132	-44,627,137,959
2028 (P)	-47,046,140,834.00	0.4665	-21,946,024,700
2029 (P)	340,016,921.00	0.4241	144,201,176
2030 (P)	67,442,021,990.00	0.3855	25,998,411,477
NPV			508,258,322,825

Table 8. NPV, IRR, PP, and PI (Cash Flow 2026-2030 down 20% per Year)

Indicator	Result	Benchmark	Description
NPV	IDR 508,258,322,825	> 0	Feasible
IRR	15.12%	> DF 10%	Feasible
PI	1.29	> 1.00	Feasible
PP	Year 2023	< Projection Period	Feasible

Even with revenue declining by 20%, the NPV remains positive at IDR 508 billion, showing a high margin of safety and strong resilience to market shocks. The IRR of 15.12% means the project remains financially profitable as long as the cost of capital does not exceed that figure. The 20% revenue decline deepens the cash-deficit period in 2025-2028, but this is still compensated by the large surplus accumulated in the early years (2022-2024).

Investment Risk with Monte Carlo Simulation (Moderate to Aggressive)

A Monte Carlo analysis with 30 simulations allows the variation of NPV values to be observed based on future revenue uncertainty. In this simulation, the researcher uses the Operating Cash Flow (2026-2030) as a random parameter with fluctuations ranging from +10% (Moderate Scenario) to +30% (Aggressive Scenario) relative to the initial projection.

Table 9. Risk Analysis with Monte Carlo Simulation (Moderate to Aggressive)

Iteration	Random Var (ε)	PV	Final NPV
1	+12.40%	108,450,210,334	841,442,598,190
2	+28.10%	245,723,897,638	978,716,285,494
3	+15.60%	136,369,676,850	869,362,064,706
4	+24.30%	212,408,212,800	945,400,600,656
5	+11.20%	98,481,116,870	831,473,504,726
6	+10.20%	89,258,567,530	822,250,955,386
7	+29.10%	254,408,652,580	987,401,040,436
8	+18.50%	161,714,007,310	894,706,395,166
9	+23.50%	205,627,883,020	938,620,270,876
10	+14.00%	122,588,786,828	855,581,174,684
11	+21.80%	190,591,327,210	923,583,715,066
12	+26.80%	234,735,993,030	967,728,380,886
13	+11.00%	96,482,457,310	829,474,845,166
14	+20.60%	180,713,787,430	913,706,175,286
15	+17.20%	150,591,787,050	883,584,174,906
16	+22.10%	193,625,882,800	926,618,270,656
17	+13.50%	118,262,347,640	851,254,735,496
18	+29.40%	257,480,237,310	990,472,625,166
19	+24.10%	210,847,212,470	943,839,600,326
20	+12.20%	106,406,103,135	839,398,490,991
21	+15.10%	132,253,347,430	865,245,735,286

Iteration	Random Var (€)	PV	Final NPV
22	+27.00%	236,374,117,305	969,366,505,161
23	+21.40%	187,408,653,240	920,401,041,096
24	+19.10%	167,153,787,640	900,146,175,496
25	+29.60%	259,824,007,420	992,816,395,276
26	+25.40%	222,737,762,690	955,730,150,546
27	+16.50%	144,411,102,910	877,403,490,766
28	+18.20%	159,372,116,980	892,364,504,836
29	+23.10%	202,287,212,470	935,279,600,326
30	+20.00%	175,716,662,362	908,709,050,218

Table 10. Summary of Monte Carlo Risk Analysis (Moderate to Aggressive)

Statistical Parameter	Value (IDR)
Highest NPV (Best Case)	992,816,395,276
Lowest NPV (Worst Case)	822,250,955,386
Mean NPV	904,551,488,225
Standard Deviation	53,442,810,450
Probability NPV > 0	100%

The simulation shows a lowest NPV (worst case) of IDR 822.25 billion, indicating that even under the most conservative operational growth (around 10%), the project still records very large economic added value, far above break-even, proving a very thick margin of safety. The most crucial finding is a probability of NPV > 0 equal to 100%: across the 30 random scenarios run, not a single result was negative. The mean NPV of IDR 904.55 billion serves as the most realistic reference for expected future profit, while the standard deviation of IDR 53.44 billion is relatively small compared with the mean, reflecting a high level of project stability against market uncertainty.

Investment Risk with Monte Carlo Simulation (Moderate to Pessimistic)

In this simulation, the researcher uses the Operating Cash Flow (2026-2030) as a random parameter with fluctuations ranging from -20% (Pessimistic Scenario) to +10% (Moderate Scenario) relative to the initial projection.

Table 11. Risk Analysis with Monte Carlo Simulation (Moderate to Pessimistic)

Iteration	Random Var (€)	PV	Final NPV
1	-7.50%	-253,027,334	622,451,200,416
2	-16.40%	-76,723,897,638	545,980,330,112
3	-8.60%	-10,369,676,850	612,334,550,900
4	+4.30%	55,408,212,800	678,112,440,550
5	-11.20%	-32,481,116,870	590,223,110,880
6	-18.20%	-97,258,567,530	525,445,660,220
7	-1.10%	11,408,652,580	634,112,880,330
8	-15.10%	-63,714,007,310	558,990,220,440
9	+3.50%	42,627,883,020	665,332,110,770
10	-20.00%	-121,588,786,828	501,115,440,922
11	-11.80%	-34,591,327,210	588,112,900,540
12	+6.80%	72,735,993,030	695,440,220,780
13	-18.00%	-92,482,457,310	530,221,770,440
14	-1.60%	-6,713,787,430	615,990,440,320
15	-14.20%	-62,591,787,050	560,112,440,700

Iteration	Random Var (ε)	PV	Final NPV
16	+2.10%	19,625,882,800	642,330,110,550
17	-3.50%	-17,262,347,640	605,441,880,110
18	-19.40%	-104,480,237,310	518,223,990,440
19	+4.10%	47,847,212,470	670,551,440,220
20	+1.20%	9,406,103,135	632,110,330,885
21	-2.10%	-12,253,347,430	610,450,880,320
22	-13.00%	-50,374,117,305	572,330,110,445
23	+2.40%	22,408,653,240	645,112,880,990
24	-10.10%	-30,153,787,640	592,550,440,110
25	-19.60%	-106,824,007,420	515,880,220,330
26	+5.40%	59,737,762,690	682,441,990,440
27	-0.50%	5,411,102,910	628,115,330,660
28	-17.20%	-82,372,116,980	540,332,110,770
29	+3.10%	36,287,212,470	658,991,440,220
30	+10.00%	92,716,662,362	715,420,890,112

Table 12. Summary of Monte Carlo Risk Analysis (Moderate to Pessimistic)

Statistical Parameter	Value (IDR)
Highest NPV (Best Case)	715,420,890,112
Lowest NPV (Worst Case)	501,115,440,922
Mean NPV	612,855,320,150
Standard Deviation	62,450,120,400
Probability NPV > 0	100%

Based on the 30 simulations, no single iteration produced a negative NPV, meaning that even with poor revenue fluctuations the PT Satya Amerta Havenport project remains mathematically profitable. The most likely NPV is around IDR 612 billion (the mean), lower than the initial scenario (IDR 732 billion) because the simulation incorporates the weight of a revenue decline of up to 20%. Statistically, the project carries a high level of confidence, and the range between the lowest and highest values (IDR 501 billion to IDR 715 billion) indicates volatility that is still manageable by the company's cash flow.

Discussion

1. Net Present Value (NPV)

The NPV analysis provides a fundamental picture of the economic value added generated by the port project over a ten-year period. Under the 30% operating cash flow growth scenario, the project produces a very significant positive NPV of IDR 732,992,387,856, reflecting that all discounted cash inflows not only cover the entire initial investment and operating costs but also generate net profit in present value. This high NPV is dominantly influenced by the massive financing cash flow in the early years (2022-2024). The financial resilience of the project is also tested through a 20% revenue-decline simulation, which still yields a positive NPV of IDR 508,258,322,825, indicating a very wide margin of safety. This result is far more optimistic than the findings of Hermawati (2011) and Yoga Budi (2021), who recorded negative NPVs for the ports they studied, and is consistent with Gina Dwi Jayanthi and Damayanti (2021) on the New Priok Port Phase 2, where large-scale infrastructure projects still produce positive economic value despite massive capital expenditure. The feasibility of this new port infrastructure also aligns with Pasetto and Giacomello (2023) at

the Port of Venice, which proved that strategic port infrastructure remains technically and economically feasible over the long term.

2. Internal Rate of Return (IRR)

The IRR serves as an indicator of capital efficiency and the investment's resilience to interest-cost burdens. Under the 30% growth scenario, the IRR is 18.45%, almost twice the assumed 10% discount factor, which is high for the capital-intensive port industry and indicates that the project remains feasible even if market lending rates rise close to that figure. Under the pessimistic scenario, the IRR corrects but remains healthy at 15.12%. The consistency of the IRR above the 10% threshold across scenarios is driven by the company's ability to achieve an operational turnaround from negative to a positive IDR 61.42 billion in 2025. This efficiency advantage is superior to I.A.P. Sri Mahapatni et al. (2023), who found an IRR of 12.25% with a very thin sensitivity threshold, and far above Zainul Aris H. and Dyah Ersita Y. (2023), who reached only 5.99%. The importance of maintaining operational efficiency to preserve financial health is also emphasized by Nguyen et al. (2024) in their evaluation of port-company business performance in Vietnam.

3. Payback Period (PP)

The Payback Period analysis shows that the investment capital is identified as recovered very quickly, namely in 2022 for the optimistic scenario and 2023 for the pessimistic scenario. This speed is not caused solely by operating profit in the early years—since operating cash flow was still negative until 2024—but by a very strong external funding structure, where financing cash flow reaching IDR 343 billion in 2022 provided instant liquidity that mathematically covered the capital expenditure incurred. This pace is very short for the port industry compared with Umbu Joka and Rifat Maromon (2019), who required 4 years and 9 months, or Lega Reskita Lubis (2018), who projected recovery of up to 13 years. The strong early funding structure mirrors the pattern found by R. Irnawati et al. (2021), where rapid liquidity is crucial to maintaining business continuity after a large investment. The company's liquidity risk management strategy ensures there is no asset-liability mismatch, a risk that often haunts long-term infrastructure projects.

4. Profitability Index (PI)

The PI provides a perspective on the efficiency of each currency unit invested. For the 30% growth scenario, the PI is 1.38, meaning that for every IDR 1,000,000 invested, the project generates a present value of IDR 1,380,000, or a 38% gain above the initial investment after considering the time value of money. Even under a 20% revenue decline, the PI remains at 1.29, so each rupiah of investment still adds 29% in value. The relatively small deviation between the optimistic (1.38) and pessimistic (1.29) PI indicates that the project is not only profitable but also carries a measurable risk of efficiency decline. These results reinforce the findings of Nurlaela Kumala Dewi et al. (2024) that a port business model (particularly a dry port) remains feasible under moderate scenarios as long as there is certainty of cargo flow, and differ from Tati Mushalihati R. et al. (2024), who found that under pessimistic scenarios a port project could become infeasible. The PI advantage here is driven by the company's strategic position as the main logistics gateway for the nickel-mining industry in North Morowali.

5. Monte Carlo Simulation Risk Analysis

To strengthen the validity of the financial findings, a Monte Carlo simulation with 30 iterations was conducted to test future cash flow uncertainty (2026-2030), incorporating random revenue fluctuations from the worst scenario (-20%) to the optimistic scenario (+10%). The mean NPV across all iterations is IDR 612,855,320,150, lower than the initial projection (IDR 732 billion) because the simulation conservatively places greater weight on revenue-decline risk, yet still strongly positive. The most crucial outcome is a probability of $NPV > 0$ of 100%, meaning that across the 30 tested future variations, no scenario causes the project to lose money. The highest achievable NPV is IDR 715.42 billion, while the lowest under the most extreme condition remains at IDR 501.11 billion, with a standard deviation of IDR 62.45 billion indicating volatility within the company's financial tolerance. This is validated by Assis et al. (2022) in Brazil, who asserted that Monte Carlo analysis (combined with real options) is far more optimal in evaluating phased port-expansion decisions under uncertainty than traditional methods such as Discounted Cash Flow, and by Godinho et al. (2022), whose stochastic Monte Carlo model provides a robust evaluation methodology that protects investors from losses due to market fluctuations. Similar high-level risk analysis is applied in the modern maritime industry by Keleştemur et al. (2024) in Türkiye and Koričan et al. (2025) in the Adriatic, the latter demonstrating life-cycle cost savings of up to 23.3%.

Conclusion

Based on the results of the analysis and discussion, it can be concluded that the investment in PT Satya Amerta Havenport's North Morowali port development project is highly feasible across all financial criteria tested. In terms of Net Present Value (NPV), the project consistently produces positive values, namely IDR 732,992,387,856 under the 30% growth scenario and IDR 508,258,322,825 even under a 20% revenue-decline scenario, indicating large absolute profit and significant added value above the 10% cost of capital over the ten-year projection period.

In terms of Internal Rate of Return (IRR), the project shows high capital efficiency with values of 18.45% in the main scenario and 15.12% in the worst-case scenario, both exceeding the 10% discount rate and indicating strong resilience to fluctuations in lending rates or the company's cost of capital. The Payback Period (PP) shows very fast capital recovery, where capital is cumulatively recovered in 2022 (optimistic scenario) or 2023 (decline scenario), much shorter than the ten-year projection period, supported by the massive injection of bank financing and equity at the start of operations. Through the Profitability Index (PI), the investment efficiency analysis yields 1.38 under the 30% growth scenario and 1.29 under the 20% decline scenario; because $PI > 1.00$, the investment is categorized as sound, with every rupiah invested generating between 1.29 and 1.38 times the capital expended.

The Monte Carlo simulation risk analysis with 30 iterations confirms that the project carries a high level of investment confidence, with a probability of $NPV > 0$ reaching 100%. Even when revenue fluctuations are tested between -20% and +10%, the mean NPV remains at IDR 612.85 billion, statistically proving that the risk of project failure is very low and that the range of financial volatility remains within limits manageable by the company. It is recommended that management maintain the momentum of operating cash flow growth, exercise caution in taking on additional debt when market rates approach the IRR, preserve adequate cash reserves to cover the projected 2025-2028 deficit phase, continuously improve operational efficiency to sustain the profitability index, and conduct periodic monitoring of

the operating cash flow variable, which is the most sensitive parameter in the risk simulation, while mitigating external impacts such as fluctuations in nickel and coal commodity prices.

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