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Tug-Barge Operating Costs Analysis based on Charterer Versus Ownership Perspective: A Case Study of Nickel Ore Transport Boenaga-Fatufia Route

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Abstract

The Tug-barge operating costs for nickel ore transhipment at Boenaga-Fatufia are based on charter and shipowner. A comprehensive study on Tug-barge investment feasibility needs to focus on the most profitable option. This study aims to determine the feasibility of investing in a Tug-barge, considering a charter Tug-barge with shipowner (newbuilding tug-barge and secondhand Tug-barge). The investment feasibility was analyzed using the Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PBP). Based on the NPV, IRR, and PBP feasibility analysis, the research results have shown that investing in a secondhand Tug-barge is feasible compared to a new building Tug-barge and charter Tug-barge. The highest NPV is for the secondhand Tug-barge, IDR 18.642.830.529; the secondhand Tug-barge also has the highest IRR value of 20%. The secondhand Tug-barge has the fastest Payback Period, which is 4.18 years.

Keywords: Tug-barge operating costs; nickel ore; investment feasibility; secondhand tug-barge

1. Introduction

Nickel ore is a prima donna commodity that attracts the industrial world in line with the increasing global demand. Digitalization and modernization in various sectors require nickel ore as raw materials, such as in making basic kitchen utensils, automotive frame manufacturing, stainless steel manufacturing materials, anti-rust coating materials, electric wires, and as the primary material for future vehicles, namely electric vehicle batteries. The policy of exporting raw materials, especially nickel ore, has been very detrimental to the Indonesian nation. This makes the Indonesian government encourage the industrial downstream program by ratifying a policy of prohibiting the export of low-grade nickel ore as stated in the Regulation of the Minister of Energy and Mineral Resources Number 11 of 2019 [1] concerning the Second Amendment to the Minister of Energy and Mineral Resources Regulation Number 25 of 2018 concerning Mineral and Coal Mining Business [2]. This policy will undoubtedly add value to commodity products and positively impact the Indonesian economy.

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The stipulation of a ban on the export of nickel ore automatically makes domestic smelters must process nickel ore. The downstream of nickel ore encourage to the shipping industry to transport this raw material because the location of the mine and smelter plant made to support the downstream nickel ore is relatively close. Therefore, a mode of transportation based on the loading and discharging port characteristics is needed for shipping this commodity.

Short Sea Shipping, can be interpreted as commercial transportation with ships that do not cross the high seas. These short sea shipping usually operate in rivers and coastal waters to deliver cargo from one port to another [3]. An alternative ship suitable for short sea shipping following the characteristics of the port for the transport of nickel ore is the Tug-barge ship. Tug-barge are highly efficient in the transportation of nickel ore. The advantage of Tug-barge ships in transporting nickel ore is easy to access, where the size of Tug-barge ship has a lower draft than other ships. Barges are mainly used to transport large and heavy cargo or equipment, which is difficult for conventional ships [4]. Tugboat ships can be used to maneuver/move, especially towing or pushing other ships in ports, the high seas, rivers, or canals. Tugboat is a ship with the uniqueness of having an enormous engine power that is disproportionate to its size [5].

In Western Europe, barge transport is used for long voyages and has become a rapidly growing mode of transport. Initially, barge transport was considered a slow, unreliable, and complex mode of transportation to integrate into the logistics system [6]. However, due to its fixed, regular sailing schedule and relatively cheap operating costs of barge transportation, transportation using barge is quite in demand.

In the operation of a ship, there are those based on charter (lease) and ownership of ships (New building ship and secondhand ship). There are three types of ship charter systems: First, there is a bareboat charter system; namely, the ship is rented empty for fuel oil, manning costs, and all costs incurred are the responsibility of the charterer. Second, in time charter system, the ship is chartered by a company within a certain period. The shipowner provides his crew and the charterer pays the rent, fuel, and towing fee. Third, Voyage Charter system or what is commonly called freight charter for one trip, the charterer will pay the mining cost (Freight Cost) to the ship owner based on the price of the cargo transported in tons [7]. In general, shipping industry costs are divided into operating costs and ship maintenance and financing costs [8]. Tug-barge's annual investment and operating costs are calculated as a percentage of the initial value of the Tug-barge investment considering ownership and operating costs (including depreciation and residual/residual), interest, maintenance and repairs, insurance, administration, and taxes [9].

In starting a business in the field of shipping, especially tug-barge shipping, an investment feasibility analysis is needed that serves to determine whether an investment is feasible to run or not. Many studies have been carried out on calculating ship investments' feasibility analysis. Examined the feasibility study of fishing vessel investment considering local wisdom, the results of this research show that fishing vessel investment is feasible to run [10]. Provides evaluation methods in investment in shipping by comparing buying a new ship versus buying a secondhand ship [11]. Examined the feasibility analysis of people's shipping ships (pelra) to Strengthen the Domestic Maritime Logistics System using the Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index, and Payback Period (PBP) analysis methods. The period of this study shows that the people's shipping business is feasible to run [12]. Conducted a feasibility study on the transportation of iron ore using a barge on the Parana-Paraguay River, as a result of their research showed that the use of a barge in the transportation of iron ore can reduce operating costs by less than 6 dollars per ton for fuel, lubricants, and maintenance [13].

The content of nickel ore in Indonesia is so abundant that Tug-barge ships are needed as an alternative to the transportation of nickel ore. Therefore, it is crucial to examine the feasibility of Tug-barge ship investment for charter-based nickel ore carriers and ship ownership (New building ships and used ships) in terms of ship operating costs incurred between charterer versus shipowner, which provide more economic benefits.

2. Methodology

The nickel ore mining location in this study was targeted at Boenaga Village, Lasolo District, North Konawe Regency, Southeast Sulawesi Province, while the Discharging port was in Fatufia village, Bahodopi District, Morowali Regency, Central Sulawesi. Regarding tug-barge ship investment data and operating costs it was collected directly by conducting observation interviews and questionnaires at loading port and discharging port. On observations, data were collected such as Tug-barge Size and Capacity, Revenue per trip, and ship operations per trip.

For the interview stage, the price of the new building ship, the Used Ship Price, and the charter price of the ship, are collected from the shipowner and the shipyard. In addition, in this step, supporting data such as the number of crew members, time and duration of operation, components of investment costs, operating costs (fuel oil, lubricating oil, fresh water, and administrative, crew, and other costs), ship repair costs, and ship maintenance costs are needed.

In this study focused on the comparison of Tug-barge operating costs between charter-based versus ownership (newbuilding ship and Secondhand ship); the size of the ship and the capacity of the Tug-barge are the same; the size and capacity of the barge is 300 ft shown in Table 1 while the power of the tugboat engine is 2 x 800 Hp shown in Table 2.

The feasibility of a Tug-barge investment is considered based on the financial parameters of Net Present Value (NPV), Internal Rate of Return (IRR) Payback Period (PBP). The followings are the formulas of NPV, IRR, PBP. The NPV [12] can be obtained by using the formula as follow:

$$NPV = \left(\sum_{t=0}^{n} \frac{NCF_t}{(1+k)^t}\right) - (NCF_0) \quad (1)$$

where t is time in year, NCF is Net cash flow, and k is the discount factor. then, the IRR [14] can be obtained by using the formula as follow:

$$IRR = i_1 + \frac{NPV_1}{NPV_1 - NPV_2(i_1 - i_2)} \quad (2)$$

where t is time in year, NVP_1 is positive net present value, NVP_2 is negative net present value and i is the discount factor. The return of the investment PBP [14] can be obtained as follow:

$$PBP = n + \frac{(a-b)}{(c-b)} x\ 1\ year \quad (3)$$

where n is latest year where the amount of cash flow is still unable to close initial investment, a is amount of initial investment, b is cumulative cash flow on n-year and c is cumulative cas flow on n+1 year.

Table 1. Main particulars and engine power of the tugboat

No	Description	Unit	Dimension
1	Main Particulars		
	a. Length over all (Loa)	m	27.00
	b. Length between perpendiculars (Lbp)	m	26.40
	c. Width (B)	m	7.50
	d. Height (H)	m	3.50
2	Main engine		
	a. Number	Unit	2
	b. Power	HP	800
3	Auxilary Engine		
	a. Number	Unit	2
	b. Power	HP	47

(Source : BKI Ship Register, 2022)

Table 2. Main particulars and engine power of the barge

No	Description	Unit	Dimension
1	Main Particulars		
	a. Length overall (Loa)	m	91.44
	b. Length between perpendiculars (Lbp)	m	87.78
	c. Width (B)	m	24.38
	d. Height (H)	m	5.48

(Source : BKI Ship Register, 2022)

3. Results and Discussion

3.1. The total investment cost of tug-barge

These three alternative Tug-barge procurement investments have consequences on Ship Operating Costs (SOC) and affect the profitability of the Tug-barge shipping business. The cashflow diagram of Tug-barge Investment between charter-based versus ownership (new building Tug-barge and secondhand Tug-barge) are shown in Fig. 1.

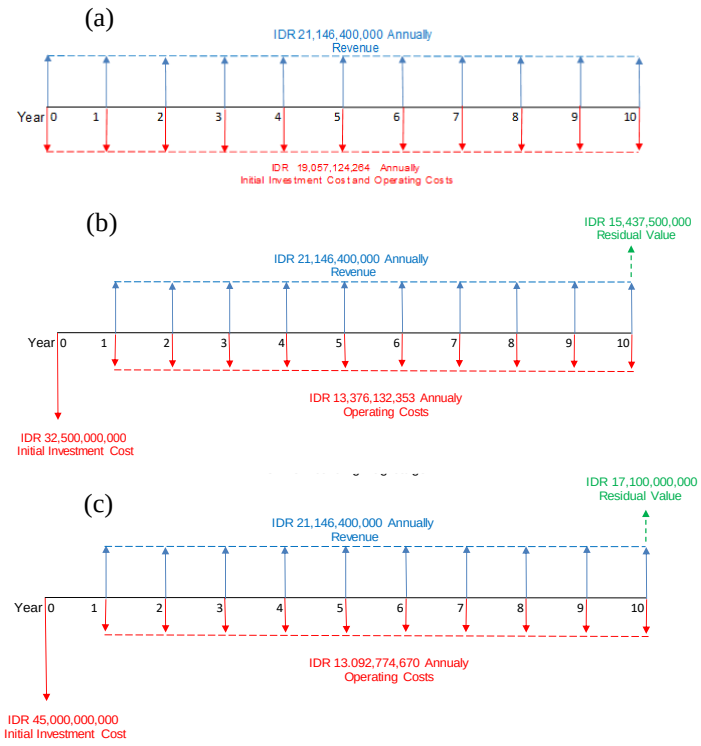

Figure 1. (a) Cash flow diagram of charter tug-barge ; (b) Cash flow diagram of secondhand tug-barge ; Cash flow diagram of new building tug-barge

All three options of Tug-barge investment are on the same ship's construction. The ship's age is assumed based on the ship's build year. The Year of Build (YOB) charter Tug-barge and secondhand Tug-barge were built in 2010, so the Ship's operational life is 13 (thirteen years). In contrast, YOB the new building Tug-barge is assumed to be 0 years. Tug-barge investment is considered feasible if the profit obtained is greater than the initial capital of the investment. The highest ship operating cost (SOC) of the three Tug-barge investment alternatives within an investment period of 10 years is the secondhand Tug-barge which is IDR 13,376,132,353 per year,while SOC of the new building Tug-barge is IDR 13,092,774,670 per year and the SOC of a Tug-barge charter ship is IDR 4,657,124,264 per year. Tug-barge still has residual value when investing in the tenth year for the secondhand and new building, while for charter Tug-barge has no residual value.

3.2. Tug-barge operation

The area of operation for transporting nickel ore in this study is in Boenaga village, Lasolo Islands District, North Konawe Regency, Southeast Sulawesi Province. As for the discharging port, it is at Jetty PT. Indonesia Morowali Industrial Park, Fatufia Village, Morowali Regency, Central Sulawesi. The Boenaga-Fatufia Operational Distance is 52,254 nautical miles (nm). WayPoint from Boenaga-Fatufia was obtained from the ship's Master and then processed by C-Maps and Google earth shown in Fig. 2.

Table 3 shows that the total sailing distance is 104.51 nm and it can be known that the sailing time of Boenaga-Fatufia is 30 hours or 1.2 days. The total time at the port is the effective time, ship waiting time, approaching time, and idle time. The total time at port for each ship can be shown in Table 4.

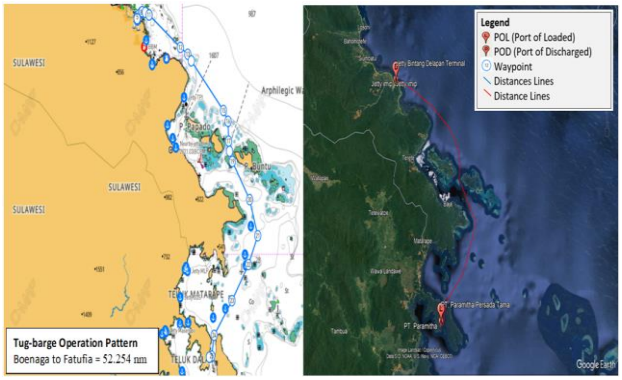

Figure 2. Round-trip operational pattern for the Boenaga-Fatufia route

Table 3. Total sailing time

Description	Speed	Distance	Time	
	Knot	nm	Hour	Day
Ballast	4	52.25	13	0.5
Laden	3	52.25	17	0.5
Total		104.50	30	1.2

Table 4. Total time at port

Port Time (Boenaga-Fatufia)	Time (Hour)
Effective Time	53.69
Waiting Time	7.57
Approaching Time	2
Idle Time	116.56
Total Port Time	179.83

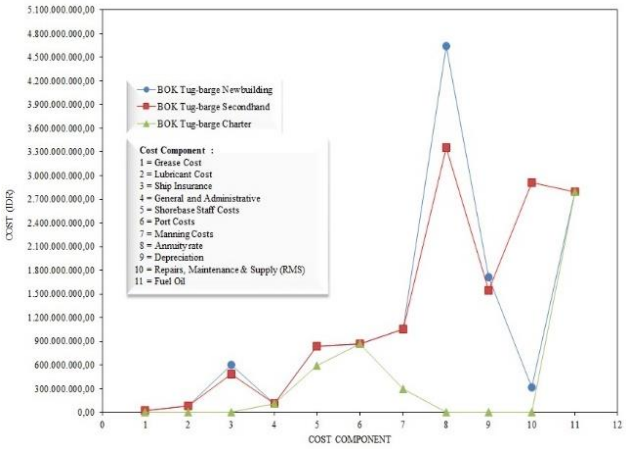

Figure 3. Operation component costs of tug-barge

Sailing time and time at the port are obtained based on the timesheet of ships owned by PT. Jelajah Samudra Bersama in May 2021. The frequency of Boenaga-Fatufia sailing in a year can reach 3-5 trips/month [15]; for this research, it is assumed that the total sailing frequencies from Boenaga-Fatufia are three trips/month.

3.3. The operation cost of the Tug-barge

The ship's operating costs are classified into direct and indirect costs, as shown in Fig. 3. Direct costs consist of two components, namely fixed costs and non-fixed costs. These fixed costs consist of depreciation costs, capital interest costs, ship insurance, and Manning costs (Crew Salary, Meal Allowance, Holiday Allowance, Towing Fee, BPJS Healthcare, BPJS Social Security, Official Clothing, and Fresh Water). Non-fixed costs consist of fuel costs, lubricant costs, grease costs, costs in the port environment, and RMS (Repairs, Maintenance & Services) fees. Indirect costs include Shore base cost, management costs, and administrative and general expenses [16].

The largest cost component of the three ship procurement investments is non-fixed costs, especially the fuel oil (BBM) cost of IDR 2.790.993.240 while the smallest cost is the grease cost of IDR 17.976.000 per year. Then Annuity rate cost of new building Tug-barge is the largest cost component IDR 4.638.490.864,55 per year.

The highest operational cost is secondhand Tug-barge IDR 13,376,132,353 per year. For newbuilding Tug-barge is IDR 13,092,774,671per year, and the smallest is the operating cost of a charter ship IDR 4,657,124,264 per year shown in Fig. 4. Charter-based operating costs are smaller than Shipowner's because the components of ship operating costs to charterers are only Manning costs, fuel costs, port costs, and shore base staff costs.

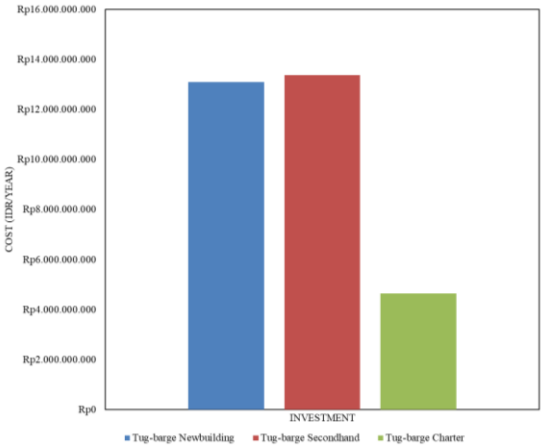

Figure 4. Total operation costs of tug-barge

Table 5. Total Revenue of tug-barge

Tug-Barge 300 FT		
Production per Trip (MT)	Unit price (IDR/MT)	Revenue(IDR)
7500	88,000	660,000,000
VAT (11%)		72,600,000
Revenue after VAT		587,400,000
Trip per mounth (3 trip/mount)		1,762,200,000
Total Trip per year (36 trip/year)		21,146,400,000

3.4. The revenue of the tug-barge

Table 5 shows the revenue of tug-barge for the Boenaga-Fatufia route. Ship revenue is obtained based on mining money (freight charter fee) per Metric Ton (MT) for one shipment or roundtrip trip. The cost of mining money for the Boenaga - Fatufia Update route on October 21, 2022, is IDR 80,000 per MT excluding 11% VAT or IDR 88,000 per MT including 11% VAT so that the total cost incurred by ship space tenants for the transportation of nickel ore cargo of ± 7500 MT once roundtrip is IDR 660,000,000 Meanwhile, the income earned by the ship owner/operator is IDR 587,400,000 for one voyage trip.

3.5. The Economic Benefit of the Tug-barge

The economic benefit of Tug-barge ship investment that gives the most profitability is the newbuilding Tug-barge ship can be shown in Fig. 5.

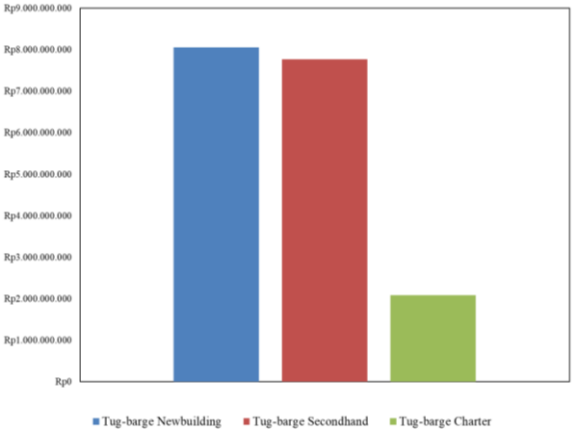

Figure 5. Total economic benefit of tug-barge

The economic benefit or profit of the Tug-barge ship can be calculated by subtracting the net income per year from the operational costs of the ship per year. The profit of the charter-based tug-barge ship for one year is IDR 2,089,275,736 per year, For Secondhand Tug-barge the profit obtained is IDR 7.770.267.647per year while the ship's profit belonging to the new building Tug-barge is IDR 8.053.625.329 per year

3.6. Investment feasibility based on Net Present Value (NPV)

The cash flow of the investment feasibility for the new building tug-barge based on Net Present Value (NPV) is shown in Table 6. The cash flow of the investment feasibility for the secondhand Tug-barge based on Net Present Value (NPV) can be shown in Table 7. And then The cash flow of the investment feasibility for the secondhand Tug-barge based on Net Present Value (NPV) shown in Table 8.

Net Present Value (NPV) calculate to assess the Tug-barge business's potential in the next ten years, considering the annual interest rate. Here, the interest rate is 8.43% regarding the Rupiah credit interest rate. According to the Bank Group; Bank Persero - Investment [17]. An investment is worth developing if the NPV is > 0.

Table 6. Net Present Value (NPV) of new building tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	- 45.000.000.000	1	- 45.000.000.000
1	8.053.625.329	0.922	7.427.488.084
2	8.053.625.329	0.850	6.850.030.512
3	8.053.625.329	0.784	6.317.467.963
4	8.053.625.329	0.723	5.826.310.027
5	8.053.625.329	0.667	5.373.337.662
6	8.053.625.329	0.615	4.955.582.092
7	8.053.625.329	0.567	4.570.305.351
8	8.053.625.329	0.523	4.214.982.340
9	8.053.625.329	0.482	3.887.284.275
10	8.053.625.329	0.445	3.585.063.428
	NPV		8.007.851.734

Table 7. Net Present Value (NPV) of secondhand tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	- 32.500.000.000	1	- 32.500.000.000
1	7.770.267.647	0.922	7.166.160.331
2	7.770.267.647	0.850	6.609.019.949
3	7.770.267.647	0.784	6.095.195.010
4	7.770.267.647	0.723	5.621.317.910
5	7.770.267.647	0.667	5.184.282.865
6	7.770.267.647	0.615	4.781.225.551
7	7.770.267.647	0.567	4.409.504.335
8	7.770.267.647	0.523	4.066.682.962
9	7.770.267.647	0.482	3.750.514.582
10	7.770.267.647	0.445	3.458.927.033
	NPV		18.642.830.528,64

Table 8. Present Value (NPV) of Charter Tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	-144.000.000.000	1	-144.000.000.000
1	16.489.275.736	0.922	15.207.300.319
2	16.489.275.736	0.851	14.024.993.377
3	16.489.275.736	0.784	12.934.606.084
4	16.489.275.736	0.723	11.928.992.054
5	16.489.275.736	0.667	11.001.560.504
6	16.489.275.736	0.615	10.146.233.057
7	16.489.275.736	0.567	9.357.403.908
8	16.489.275.736	0.523	8.629.903.078
9	16.489.275.736	0.483	7.958.962.536
10	16.489.275.736	0.445	7.340.184.945
	NPV		-35.469.860.136,11

From the perspective of a Tug-barge Owner, the NPV value is Positive, so this investment is economically feasible. While the charter Tug-barge investment-based charterer perspective over ten years shows a negative value. Because the NPV is less than zero or is negative, the investment is not feasible.

3.7. Investment feasibility based on Internal Rate of Return (IRR)

The cash flow of the investment feasibility for the new building Tug-barge based on Internal Rate of Return (IRR can be shown in Table 9 . The cash flow of the investment feasibility for the secondhand Tug-barge based on Internal Rate of Return (IRR) shown in Table 10. And the cash flow of the investment feasibility for the charter Tug-barge based on Internal Rate of Return (IRR) can be shown in Table 11.

The primary function of calculating IRR is to measure the value of an asset return. The calculation of the IRR also has the advantage of knowing the return on invested capital, making it possible to assess the performance of any form of activity accurately.Internal Rate of Return generated on investment in new building Tug-barge for ten years is 12% or greater than the discount factor of 8.43%, so the investment is feasible. Internal Rate of Return generated on investment in secondhand Tug-barge for ten years is 20% or greater than the discount factor used rate of 8,43%, so the investment is feasible.

Table 9. Internal Rate of Return (IRR) of New Building Tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	- 45.000.000.000	1	- 45.000.000.000
1	8.053.625.329	0.922	7.427.488.084
2	8.053.625.329	0.850	6.850.030.512
3	8.053.625.329	0.784	6.317.467.963
4	8.053.625.329	0.723	5.826.310.027
5	8.053.625.329	0.667	5.373.337.662
6	8.053.625.329	0.615	4.955.582.092
7	8.053.625.329	0.567	4.570.305.351
8	8.053.625.329	0.523	4.214.982.340
9	8.053.625.329	0.482	3.887.284.275
10	8.053.625.329	0.445	3.585.063.428
	IRR		12%

Table 10. Internal Rate of Return (IRR) of secondhand tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	-32.500.000.000	1	-32.500.000.000
1	7.770.267.647	0.922	7.166.160.331
2	7.770.267.647	0.850	6.609.019.949
3	7.770.267.647	0.784	6.095.195.010
4	7.770.267.647	0.723	5.621.317.910
5	7.770.267.647	0.667	5.184.282.865
6	7.770.267.647	0.615	4.781.225.551
7	7.770.267.647	0.567	4.409.504.335
8	7.770.267.647	0.523	4.066.682.962
9	7.770.267.647	0.482	3.750.514.582
10	7.770.267.647	0.445	3.458.927.033
	IRR		20 %

Table 11. Internal Rate of Return (IRR) of charter tug-barge

Years	Net Income (IDR)	df 8.43%	PV(IDR)
0	- 144.000.000.000	1	-144.000.000.000
1	16.489.275.736	0.922	15.207.300.319
2	16.489.275.736	0.851	14.024.993.377
3	16.489.275.736	0.784	12.934.606.084
4	16.489.275.736	0.723	11.928.992.054
5	16.489.275.736	0.667	11.001.560.504
6	16.489.275.736	0.615	10.146.233.057
7	16.489.275.736	0.567	9.357.403.908
8	16.489.275.736	0.523	8.629.903.078
9	16.489.275.736	0.483	7.958.962.536
10	16.489.275.736	0.445	7.340.184.945
	IRR		3 %

Whereas in the Internal Rate of Return generated on the investment in the Tug-barge Charter for ten years is 3 % or less than the discount factor used rate of 8,43%, so the investment is not feasible to run.

Table 12. Payback Period (PBP) of new building tug-barge

Years	Net Income (IDR)	Balance (IDR)
0	-45.000.000.000	-45.000.000.000
1	8.053.625.329	-36.946.374.671
2	8.053.625.329	-28.892.749.341
3	8.053.625.329	-20.839.124.012
4	8.053.625.329	-12.785.498.682
5	8.053.625.329	-4.731.873.353
6	8.053.625.329	3.321.751.976
7	8.053.625.329	11.375.377.306
8	8.053.625.329	19.429.002.635
9	8.053.625.329	27.482.627.964
10	8.053.625.329	35.536.253.294
	PBP	5.58

Table 13. Payback Period (PBP) of secondhand tug-barge

Years	Net Income (IDR)	Balance (IDR)
0	-32.500.000.000	-32.500.000.000
1	7.770.267.647	-24.729.732.353
2	7.770.267.647	-16.959.464.706
3	7.770.267.647	-9.189.197.059
4	7.770.267.647	-1.418.929.412
5	7.770.267.647	6.351.338.235
6	7.770.267.647	14.121.605.882
7	7.770.267.647	21.891.873.529
8	7.770.267.647	29.662.141.176
9	7.770.267.647	37.432.408.823
10	7.770.267.647	45.202.676.470
	PBP	4.18

Table 14. Payback Period (PBP) of charter tug-barge

Years	Net Income (IDR)	Balance (IDR)
0	-144.000.000.000	-144.000.000.000
1	16.489.275.736	-127.510.724.264
2	16.489.275.736	-111.021.448.528
3	16.489.275.736	-94.532.172.792
4	16.489.275.736	-78.042.897.056
5	16.489.275.736	-61.553.621.320
6	16.489.275.736	-45.064.345.584
7	16.489.275.736	-28.575.069.848
8	16.489.275.736	-12.085.794.112
9	16.489.275.736	4.403.481.624
10	16.489.275.736	20.892.757.360
	PBP	8.73

3.8. Investment feasibility based on Payback Period (PBP)

The cash flow of the investment feasibility for the new building Tug-barge based on Payback Period (PBP) can be shown in Table 12. The cash flow of the investment feasibility for the Secondhand Tug-barge based on Payback Period (PBP) shown in Table 13. And then the cash flow of the investment feasibility for the charter Tug-barge based Payback Period (PBP) can be shown in Table 14.

The payback period (PBP) is the return on invested capital or the time it takes to make a profit. Based on the investment feasibility analysis of the three options using the payback period (PBP) method, the fastest return on investment within ten years is the secondhand Tug-barge compared to the new building and charter Tug-barge.

4. Conclusion

Investment Feasibility for the three Tug-barge procurement alternatives is feasible to run. If assessed based on the investment feasibility method by using Net Present Value, Internal Rate of Return (IRR), Payback Period (PBP) within ten years, the secondhand Tug-barge is the most profitable. Of course, the basis for chartering and purchasing a Set of Tug-barge certainly should look investor's financial condition or the shipping company

itself. Charter is the most realistic and affordable option if a company has limited money and wants to charter a set of Tug-barge in just a few months or years. Investment Feasibility of charter Tug-barge and ownership of Tug-barge (Secondhand and New building) indicated to have suffered losses is a charter-based ship investment. Moreover, suppose the investment for charter-based Tug-barge continues within ten years. In that case, the economic benefits obtained are minimal compared to the Tug-barge ownership investment. The scheme of two barges and one tugboat for nickel ore transhipment needs further research, Then several methods related to feasibility investment with several approach : Average Rate of Return (ARR), Return of Investment (ROI), Profitability Index (PI), and Discount Payment Period (DPP) to assess financial parameters.

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