

Analytical model for the ship purchase and maintenance decision in the new economy

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Abstract. The maritime industry is currently increasing, and the industry will continue to grow due to the rapid growth of the global economy. The industry and the business of maritime companies bring with them the issue of vessel renewal and repair. To explore the impact of vessel renewal or repair on the company's benefits, we conducted a simulation experiment focusing on how the company should ensure maximum benefits if the vessel needs to be repaired. On the one hand, repair the vessel to continue operations. On the other hand, new vessels are purchased to replace the old ones. According to the data, Shipping companies make higher profits by replacing their vessels with new ones.

Keywords: Engineering economy; Supply chain management; Maritime transport, production, periodic maintenance/repair, life cycle/earning, net present value, scantling optimization.

1. Introduction

As the maritime industry grows, more and more shipping companies are choosing to expand their routes and vessel operations. This has led to a challenge for shipping companies to repair vessels or purchase new ones. Shipowners can usually agree on maintenance contracts with ship repair yards in terms of maintenance. This allows both partners to reduce their financial risk by offering discounts or favorable payment terms. The ship repair yard determines how long to extend the repair amount by rating the shipping company. The result is that the shipping company increases the company's operating earnings and cash flow after returning the ship while ensuring that cash outlays are minimized (LOGES, 2021). Although the overall cost of maritime crewing fell by 1.8% in 2018 compared to 1.3% in 2017, the survey found that the cost of repairs and vessel maintenance is still steadily rising (Survey finds repairs and maintenance costs up but overall costs down for seventh year, 2019). This leaves both shipbuilders and shipping companies facing different risks and rewards. In addition, the ship repair market faces a significant challenge in the form of increased raw material and logistics costs due to the Covid-19 epidemic (Roussanoglou, 2021). Shipowners prefer the multiple booking approach to hedge the risks and impacts of unforeseen future scenarios. This situation has resulted in ship repair yards having only minimal repair options and ships. In addition, considering the different types of cargo markets, customer demands, and expectations vary by industry resulting in container and bulk container owners being more willing to pay high repair costs to reputable ship repair yards. This is because they do not want to postpone the repair time resulting in the customer's cargo not being delivered on time (Roussanoglou, 2021).

1.1 Decision background

Now, NETCO Shipping is facing the problem of economic choice for the old vessel Vital Spark. According to the description of NETCO's CFO and Chief Engineer, several options were presented: The Vital Spark freighter would remain in service after repairs, or a new vessel from Cohn and Doyle would replace it. The company would like to choose an alternative that maximize their profit with the prerequisite of same level transportation performance.

1.2 Analysis Schema

This paper will strictly follow the seven steps of engineering economics during the analysis (Sullivan, Wicks and Koelling, n.d). First, problem definition and assumptions will be made. Then,

alternative scenarios and cash flow tables will develop and selected criteria. After this, the data will be compared and selected to conclude. In addition, the researcher will perform sensitivity analysis on certain variables depending on the situation and extend it to explore other relevant information for risk and audit assessment.

1.3 Basic conclusions

1.4 General Assumptions

During the whole analysis of the project, we make the following assumptions:

- The after-tax MARR is: $MARR_a = \text{Capital Cost} * (1 - \text{tax rate})$;
- Only actual dollar will be taken into consideration.
- We don't know which month is at Year 0, the inflation base year will be treated as Year 1.
- Sensitivity analysis will be conducted on 3 variables: tax rate, inflation rate and cost of capital. The tuning steps and ranges are as follow in table 1.

2. Solutions and sensitivity analysis of New Economy Transport Problem A

2.1 Problem description

Two alternatives were raised to keep its 25-year-old vessel Vital Spark: in use: to undergo an overhaul (donated by OH), or to install with brand-new engine and control system (donated by NE). Both alternatives will generate capital investment (for the overhaul and installation) and operating or maintenance expenditures through its useful life. Alternatives is as follow:

Alternative OH: Overhaul the vessel now at a total expenditure of \$820,000 and maintain a post overhaul operating cost of \$1,181,000 per year till the vessel scrapped.

In additional, there are two choices provided for the company: overhaul the vessel with or without NECS1. While NECS will bring in cost reduction, it will also need more investment. The company should decide whether it is profitable to make the additional investment in NECS.

2.2 Assumption 1

Based on our understandings of NETCO's situation at present, the following assumptions will be taken throughout the whole comparison analysis between OH vs. NE.

- The depreciation base contains book value of vessel (\$100,000), the overhaul cost plus the extra cost of new engine (only for NE), excluding the value of spare parts.
- The recovery period of depreciation follows 7-year MACRS class.
- Annual cost will increase with a constant inflation rate from the 2nd year.
- The useful life of Vital Spark is 10,11 or 12 years, which will be analyzed respectively.

2.3 Spreadsheets and results

Our choice of comparison criterion is Net present value (NPV), we also consider indicators of ATCF, NOPAT and EVA. According to spreadsheet analysis (see Table 1.2~1.7 in appendix), results are shown in the Table 2.

Table 2. The comparison results.

	10 useful life	11 useful life	12 useful life
OH (HPV) \$	430181.38	283151.12	336539.19
NE (HPV) \$	801764.08	548935.31	641572.15

The yearly cash flow, EVA and NOPAT are shown in Figure 1.1 below. Here we only take 10 Useful life as an example (see diagrams of 11,12 useful life, Figure 1.2~1.3 in appendix).

In conclusion, no matter the useful life of Vital Spark is 10, 11 or 12, on the criterion of NPV, NE is always better than OH. Additionally, when the vessel can be used 10 more years, the NE profit will be the most. However, although the breakeven points of NE and OH are the same (Year 7), from the cash flow diagram, we can see that EVA and NOPAT of NE for the first several years is lower than OH, which may be considered for the decision.

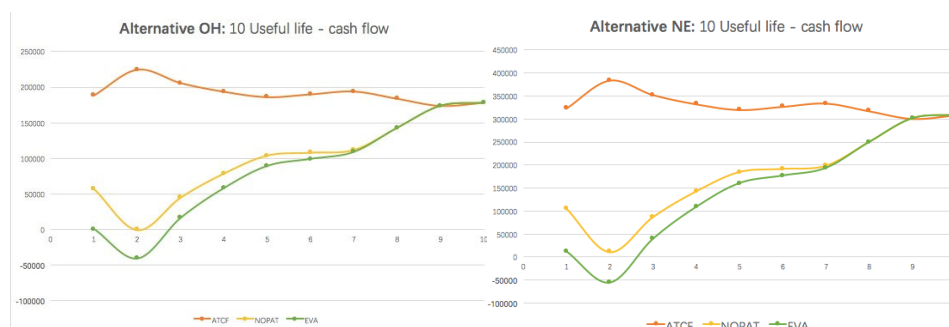


Fig 3: Cash flow diagram OH vs. NE (useful life 10).

2.4 Sensitivity Analysis (adjustment to reality)

When the 3 variables (tax rate, inflation rate & cost of capital) varied in our pretended range, NE is always better than OH. One special situation happens when the cost of capital is higher than 28%, both NE and OH will change to be samely unprofitable. (See Figure 1.4~1.6 in appendix)

3. Solutions and sensitivity analysis of New Economy Transport Problem B

3.1 Problem description

Part (B) requires us to calculate and compare the equivalent annual cost of (a) overhauling and operating the Vital Spark for 12 more years, and (b) buying and operating the proposed replacement vessel for 20 years or more, here we set the time period as 21 years.

Estimated annual operating cost of the new vessel is \$885000 in total. Besides, training is required and would cost \$50000 next year. The new vessel would generate additional annual revenue \$100000, so the annual revenue adds up to \$1500000, still increasing with inflation rate. The new vessel is offered for a price of \$3000000, payable half immediately and half on delivery next year. Vital Spark has a net value of only \$100000 and the book value of the spare parts is \$40000, but the vessel could be sold with an extensive inventory of spare parts for \$200000. Therefore, the sale of Vital Spark would generate an immediate tax liability of \$140000.

3.2 Assumptions

Based on the current situation, the following Assumptions are taken in this problem:

- We use ten-year MACRS class for the new vessel to calculate the depreciation for tax purpose.
- All the cost would be calculated with tax and we treat the training fee as operating cost.
- We set the time period of the new vessel as 21 years; the time period of the old vessel is 11 years.
- We assume that the cost of repairment for the new vehicle is included in other cost.
- Taking the tax liability of \$140000 into the income calculation.

3.2.1 Given assumptions

- (1) Training crews to get additional ability to handle the more complex and sophisticated equipment will cost \$50,000 next year.
- (2) We might even be able to sell or scrap her for book value when her replacement arrives.
- (3) The new vessel should be able to handle a larger load on some routes, which could generate additional revenues, net of additional out-of-pocket cost, of as much as \$100,000 per year.
- (4) The new vessel for a fix prices of \$3,000,000, payable half immediately and half on delivery next year.
- (5) A new vessel would have a useful service life of 20 years or more.

3.2.2 The assumptions we made

- (1) The new vessel only can be used in the second year.
- (2) This problem has to situations:
The first one is the old vessel can still be used one more year. (1) The old vessel would cost \$1,3000,000 next year if we use it. Because if we don't overhaul it, the fuel and maintenance cost of the old vessel will be higher than the overhauled vessel. (2) It can still earn \$1,400,000 next year. (3) In this year, we can consider outlays could be depreciated for tax purpose in the seven-year MACRS class.
The second one is we sell the vessel right now.
- (3) The revenue of changing the new vessel will increase year by year caused by the inflation.
- (4) We can consider new vessel could be depreciated for tax purpose in the 10-year MACRS class.

3.3 Spreadsheets and Results

Due to the fact that we only consider the cost, the EVA and NOPAT is not suitable for the evaluation, we only consider ATCF and annual cost in this part. Except for the first year, the ACTF of changing a new ship for each year is always less than overhauling and operating the old ship, taking consideration of the selling price of the first year, the comparison is shown in Table 2.1 and Figure 2.1 in the appendix.

We simply analyze the cost of (a) and (b), due to their different time period, we calculate the total cost at year 0 and convert it into annual cost, then make the comparison. The results are shown in Table 4 below. The cost of buying a new vessel is higher. The computation process is shown in Table 2.3 and Table 2.4 in appendix.

Table 4. The comparison results (cost only)

Category	Total cost	Annual Cost
Overhauling the Vital Spark	-6985596.030	-1125526.268
Buying a new vessel	-9133008.757	-1471519.569
Category	Total cost	Annual Cost

3.4 Sensitivity Analysis (adjustment to reality)

We conduct sensitivity analysis with 3 variables (tax rate, inflation rate & cost of capital) varied in our pretended range. For tax rate and MARR, we find that the annual cost both decreases with tax rate increases. For inflation rate, the annual cost both decreases with inflation increases. However, the annual cost of (b) buying a new vessel is always lower than (a) overhauling the Vital Spark. The process is shown in the Figure 2.2~2.4 in appendix.

4. Solutions and sensitivity analysis of New Economy Transport Problem B (considering revenue)

Based on the information and assumptions in Part 2, analysis on equivalent annual cost has shown that ATCF of changing a new vessel is always less than overhauling the old ship. However, since the new vessel is more profitable, we cannot directly draw a conclusion. In this part, we add revenue into

the calculation of equivalent annual ATCF and compare the defender and the challenger. The results are given in Table 3.1 below, Apparently, it's a better choice to change a new vessel when revenue is considered. The process is shown in the Table 3.2 and 3.3 in appendix. Besides, the comparison of NOPAT, ATCF and EVA is shown in Figure 3.1 and 3.2 in appendix.

Table 5: The comparison results (considering the revenue)

Operation	Annual ATCF
Defender (overhauling the Vital Spark)	80243
Challenger (buying a new vessel)	301936

4.1 Sensitivity Analysis

We also conduct sensitivity analysis in this part, based on the same parameters and same range of variation.

As is shown in Figure 3.3~3.5 in the appendix, the equivalent annual ATCF decreases as capital cost and tax rate increases, while increases as inflation rate increases. This is easy to explain, since the increase of revenue is only based on inflation rate and we only consider actual dollar. The plots also show that changing a new vessel is always a better choice when parameters vary in the given ranges.

5. Thin twice and extension in New Economy Transport Problem B

5.1 Think twice: the appropriate time to make the replacement

In reality, the choices Mr. Handy faces are much more than what we have discussed above. For example, he can overhaul the old vessel, keep it running for 5 or 10 years and make the replacement. We compute the annual equivalent after tax cash flow for alternatives respectively and derive $AW_{5\text{years}}=48125$, $AW_{10\text{years}}=74864$. Both are smaller than the annual worth of the challengers. So it's advisable to place the order for replacement now.

5.2 Extension: sell the old vessel now or next year?

As above, it is more profitable to place the order for a new vessel right now. However, should he scrap the vessel right now or keep it running until the replacement is ready? There is a tradeoff here: keeping the old vessel running will yield revenues but its market value will decrease with time. The decision depends on the months left this year and the estimated revenue.

Considering inflation, monthly expense of operating and revenue this year is:

$$R_m = 1,400,000 / (1.025 \times 12) = 113,821\$ \quad (1)$$

$$E_m = 1,181,000 / (1.025 \times 12) = 96,016\$ \quad (2)$$

Also, we should estimate the monthly depreciation. The old vessel is 25 years old, but still has a book value of \$100,000. Suppose that the company uses SL method, the initial book value of the vessel is:

$$BV_0 = 3,000,000 / 1.025^{25} = \$1,168,172, \quad (3)$$

and the monthly depreciation is :

$$d_m = (1,168,172 - 100,000) / (25 \times 12) = \$5,061, \quad (4)$$

Table 6. The total after tax cash flow

Months left	Total ATCF	Months left	Total ATCF
1	108,283.60	7	157,985.20
2	116,567.20	8	166,268.80

3	124,850.80	9	174,552.40
4	133,134.40	10	182,836
5	141,418	11	191,119.60
6	149,701.60	12	199,403.20

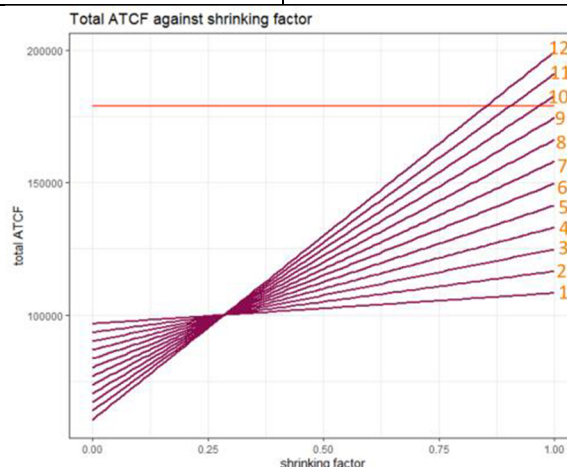


Fig 1: Total ATCF- shrinking factor

We can conclude that only when there is more than 10 months left this year is it wise to keep the old vessel running. However, the gross profit (revenue- expense) might not be as high as the profit after overhauling. Multiply it by a shrinking factor s between 0 and 1 and we derive the Figure 4.1 above. It can be concluded from the chart that only when there are more than 10 months left and the shrinking factor is no less than 0.85 should Mr. Handy consider keeping the old vessel running. The process is shown in Table 4.2 in appendix.

6. Additional information

If the equivalent annual cost of the replacement is higher, we should collect some additional information as follows:

6.1 The payback period for investment replacements should be considered

You need to gather information about the specific business value that the replacement can bring and figure out how many years it will take to recoup the initial investment. This examines the liquidity of capital and is important information for making choices.

6.2 Recognition and acceptance of past errors

To decide on whether to take a replacement, we should firstly draw the cash flows of these two schemes. Then we should compare their Income and expenditure situations. We need to have a clear recognition of them and if needed, we should accept that we may have made some mistakes in the past times. Finally, we can make an objective choice.

6.3 Sunk costs

When deciding whether to perform the replacement operation, we should consider the sunk cost. The initial investment cost and current income of vital spark, the cost of additional investment if the maintenance operation is carried out, etc. These investment funds, i.e. sunk cost, should be considered when deciding whether to replace defender with challenger.

6.4 Existing asset value and the outsider viewpoint

When considering replacement decisions, you also need to know the value of existing assets. If you want to replace defender with challenger, you must sell the original vital spark. When you sell it, you need to know clearly how much it will cost and how much it will recover. Only with (2) (3) these data and the company's Marr can we calculate the CR of vital spark.

6.5 Economic life of the proposed replacement asset(challenger)

Mr. handy also needs to know some data about the replacement. For example, the economic life of a replacement, the number of years it can work normally, whether it needs to be repaired, how often it needs to be repaired, how much it costs to repair, and how much it benefits from normal work, etc.

6.6 Remaining (economic) life of the old asset (defender)

In addition to considering some data of replacement, learn more about defender. For example, how much book depreciation will be generated in its remaining economic life, whether the depreciation generated can be offset by the income or whether the income generated is higher than the replacement, etc.

6.7 Income tax considerations

When considering cost and income, we should also consider the issue of tax. The continued use of vital spark will generate tax depreciation, and the issue of threshold and gradient tax collection also needs to be considered, so it is necessary to know the specific data of tax.

Mr. handy also needs to focus on the issue of study period. The company hopes to measure the benefits of the two schemes (replacing or not replacing) (more specifically, which year to replace) in the coming years.

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Appendix

Table 1.2 Spreadsheet for 10 Useful life OH

		2	3	4	5					
Initial Outlay	-920000.00									
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16
Operating Costs	-1181000.00	-1210525.00	-1240788.13	-1271807.83	-1303603.02	-1336193.10	-1369597.83	-1403863.88	-1438893.82	-1474907.17
Depreciation	131468.00	225308.00	160908.00	114908.00	82156.00	82064.00	82156.00	41032.00	0.00	0.00
Taxable Income	87532.00	-833.00	69178.87	120931.05	159579.02	165714.40	171816.86	219290.18	266830.23	273500.99
Taxes	30636.20	-291.35	24212.61	42325.87	55852.68	58000.04	60135.90	76751.56	93390.58	95726.35
ATCF	188363.80	224766.55	205874.27	193513.18	185882.36	189778.36	193836.96	183570.62	173439.65	177775.64
NOPAT	56895.80	-541.45	44966.27	78605.18	103726.36	107714.36	111680.96	142538.62	173439.65	177775.64
IRR (ATCF)	9.1674948									
Book Value	788532.00	563224.00	402316.00	287408.00	206252.00	123188.00	41032.00	0.00	0.00	0.00
EVA	515.76	-40811.97	16200.67	58055.51	89050.85	98906.42	108747.17	142538.62	173439.65	177775.64
Present Value for Each year (11%)	-920000.00	175794.49	195770.54	167349.83	146905.34	131606.40	125398.87	119533.97	105649.09	93157.71
NPV of the overhaul without brand-new engine and control system	430181.38									

Table 1.3 Spreadsheet for 10 Useful life NE

		2	3	4	5					
Initial Outlay	-1520000.00									
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16
Operating Costs	-1020000.00	-1045500.00	-1071637.50	-1096428.44	-1122869.15	-1150036.39	-1178297.29	-1212459.47	-1242770.96	-1273840.23
Depreciation	217208.00	372248.00	265848.00	189848.00	135736.00	135584.00	135736.00	67792.00	0.00	0.00
Taxable Income	162792.00	17252.00	133389.50	219370.44	283712.90	294351.12	304947.50	383908.59	462993.10	474567.93
Taxes	56977.20	6038.20	46686.32	76779.65	89299.51	103022.89	106731.62	134268.01	162047.59	166098.78
ATCF	323022.80	383461.80	352551.18	332438.78	320149.38	326912.23	339951.87	317332.58	300945.52	308469.15
NOPAT	105814.80	11213.80	86703.17	142590.78	184413.38	191328.23	198215.87	249540.58	300945.52	308469.15
IRR (ATCF)	0.1785485									
Book Value	1302792.00									
EVA	12665.17									
Present Value for Each year (11%)	-1520000.00	301457.85								
NPV of the overhaul without brand-new engine and control system	801764.08									

Table 1.4 Spreadsheet for 11 Useful life OH

		1	2			6	7	8	9	10	11
Initial Outlay	-920000.00										
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16	1792118.36
Operating Costs	-1141000.00	-1210525.00	-1249796.13	-1271807.83	-1309639.02	-1336193.10	-1369597.95	-1403937.88	-1438953.92	-1474007.17	-1511779.85
Depreciation	131498.00	225308.00	160908.00	114908.00	82156.00	82064.00	82156.00	41032.00	0.00	0.00	0.00
Taxable Income	87532.00	803.00	69178.87	120931.05	159579.02	165714.40	171816.88	210290.18	268830.23	273900.99	280338.52
Taxes	30636.20	-291.35	24212.61	42325.67	55852.66	58000.04	60135.90	76751.56	93390.58	95725.35	98118.48
ATCF	188363.80	224766.55	205874.27	193513.18	185882.36	189778.36	193836.98	183570.62	173439.65	177775.64	182220.03
NOPAT	56895.80	541.45	44966.27	78605.18	103726.36	107714.36	111680.96	142538.62	173439.65	177775.64	182220.03
IRR (ATCF)	0.1770287										
Book Value	788532.00	563224.00	402316.00	287408.00	205252.00	123188.00	41032.00	0.00	0.00	0.00	0.00
EVA	515.76	-4081.97	16200.67	58055.51	89050.85	98906.42	108747.17	142538.62	173439.65	177775.64	182220.03
Present Value for Each year (11%)	-920000.00	169697.12	182425.57	150533.48	127473.13	110312.14	101463.26	93363.20	79656.15	67801.86	62609.82
NPV of the overhaul without brand-new engine and control system	283151.12										

Table 1.5 Spreadsheet for 11 Useful life NE

		1	2			6	7	8	9	10	11
Initial Outlay	-1520000.00										
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16	1792118.36
Operating Costs	-1020000.00	-1045500.00	-1071637.50	-1096428.44	-1122869.15	-1150036.39	-1178297.29	-1212459.47	-1242770.96	-1273840.23	-1305688.24
Depreciation	217208.00	372248.00	265848.00	189848.00	135736.00	135584.00	135736.00	67792.00	0.00	0.00	0.00
Taxable Income	162792.00	17252.00	133389.50	219370.44	283712.90	294351.12	304947.50	383908.59	462993.10	474567.93	486432.13
Taxes	56977.20	6038.20	46686.32	76779.65	89299.51	103022.89	106731.62	134268.01	162047.59	166098.78	170251.24
ATCF	323022.80	383461.80	352551.18	332438.78	320149.38	326912.23	339951.87	317332.58	300945.52	308469.15	316180.88
NOPAT	105814.80	11213.80	86703.17	142590.78	184413.38	191328.23	198215.87	249540.58	300945.52	308469.15	316180.88
IRR (ATCF)	0.1877494										
Book Value	1302792.00	930544.00	664696.00	474848.00	339112.00	203526.00	67792.00	0.00	0.00	0.00	0.00
EVA	12665.17	-55320.10	39177.41	109639.15	160166.88	176775.98	193368.75	249540.58	300945.52	308469.15	316180.88
Present Value for Each year (11%)	-1520000.00	291011.53	311226.20	257782.38	219987.72	189993.08	174780.63	160850.73	137699.02	117647.06	106838.05
NPV of the overhaul without brand-new engine and control system	548935.31										

Table 1.6 Spreadsheet for 12 Useful life OH

		1	2	3			7	8	9	10	11	12
Initial Outlay	-920000.00											
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16	1792118.36	1836921.32
Operating Costs	-1141000.00	-1210525.00	-1249796.13	-1271807.83	-1309639.02	-1336193.10	-1369597.95	-1403937.88	-1438953.92	-1474007.17	-1511779.85	-1549574.34
Depreciation	131498.00	225308.00	160908.00	114908.00	82156.00	82064.00	82156.00	41032.00	0.00	0.00	0.00	0.00
Taxable Income	87532.00	803.00	69178.87	120931.05	159579.02	165714.40	171816.88	210290.18	268830.23	273900.99	280338.52	287348.98
Taxes	30636.20	-291.35	24212.61	42325.67	55852.66	58000.04	60135.90	76751.56	93390.58	95725.35	98118.48	100571.44
ATCF	188363.80	224766.55	205874.27	193513.18	185882.36	189778.36	193836.98	183570.62	173439.65	177775.64	182220.03	186775.54
NOPAT	56895.80	541.45	44966.27	78605.18	103726.36	107714.36	111680.96	142538.62	173439.65	177775.64	182220.03	186775.54
IRR (ATCF)	0.1845175											
Book Value	788532.00	563224.00	402316.00	287408.00	205252.00	123188.00	41032.00	0.00	0.00	0.00	0.00	0.00
EVA	515.76	-4081.97	16200.67	58055.51	89050.85	98906.42	108747.17	142538.62	173439.65	177775.64	182220.03	186775.54
Present Value for Each year (11%)	-920000.00	169697.12	182425.57	150533.48	127473.13	110312.14	101463.26	93363.20	79656.15	67801.86	62609.82	57815.38
NPV of the overhaul without brand-new engine and control system	336539.19											

Table 1.7 Spreadsheet for 12 Useful life NE

		1	2				7	8	9	10	11	12
Initial Outlay	-1520000.00											
Revenue	1400000.00	1435000.00	1470875.00	1507646.88	1545338.05	1583971.50	1623570.79	1664160.06	1705764.06	1748408.16	1792118.36	1836921.32
Operating Costs	-1020000.00	-1045500.00	-1071637.50	-1096428.44	-1122869.15	-1150036.39	-1178297.29	-1212459.47	-1242770.96	-1273840.23	-1305688.24	-1338328.30
Depreciation	217208.00	372248.00	265848.00	189848.00	135736.00	135584.00	135736.00	67792.00	0.00	0.00	0.00	0.00
Taxable Income	162792.00	17252.00	133389.50	219370.44	283712.90	294351.12	304947.50	383908.59	462993.10	474567.93	486432.13	498592.93
Taxes	56977.20	6038.20	46686.32	76779.65	89299.51	103022.89	106731.62	134268.01	162047.59	166098.78	170251.24	174501.33
ATCF	323022.80	383461.80	352551.18	332438.78	320149.38	326912.23	339951.87	317332.58	300945.52	308469.15	316180.88	324065.40
NOPAT	105814.80	11213.80	86703.17	142590.78	184413.38	191328.23	198215.87	249540.58	300945.52	308469.15	316180.88	324065.40
IRR (ATCF)	0.1849939											
Book Value	1302792.00	930544.00	664696.00	474848.00	339112.00	203526.00	67792.00	0.00	0.00	0.00	0.00	0.00
EVA	12665.17	-55320.10	39177.41	109639.15	160166.88	176775.98	193368.75	249540.58	300945.52	308469.15	316180.88	324065.40
Present Value for Each year (11%)	-1520000.00	291011.53	311226.20	257782.38	219987.72	189993.08	174780.63	160850.73	137699.02	117647.06	106838.05	92536.84
NPV of the overhaul without brand-new engine and control system	641572.15											

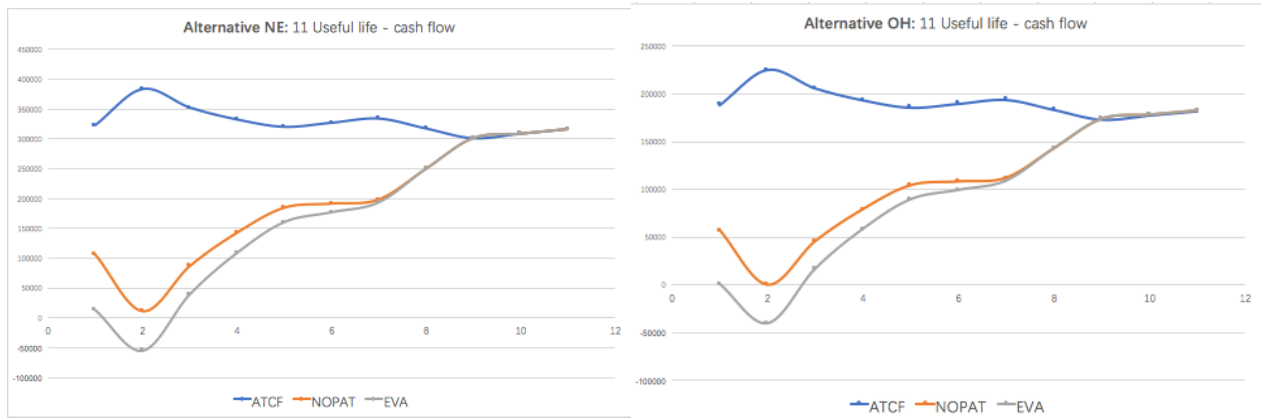
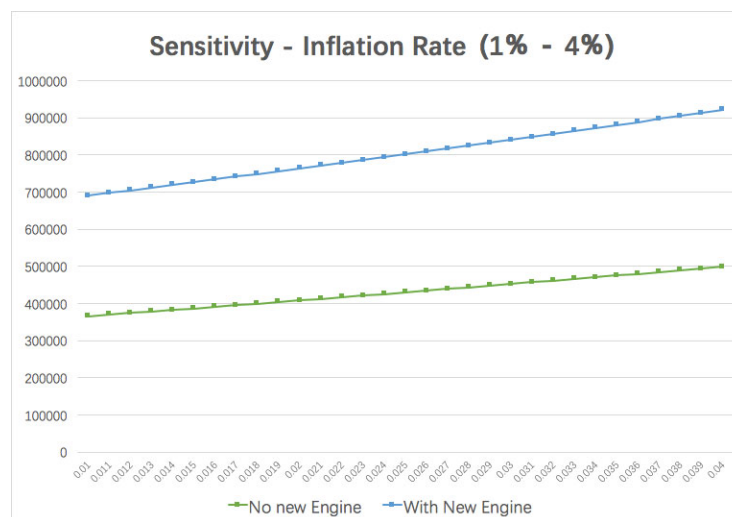


Figure 1.2 Cash flow diagram OH (useful life 11)



Figure 1.3 Cash flow diagram OH (useful life 12)



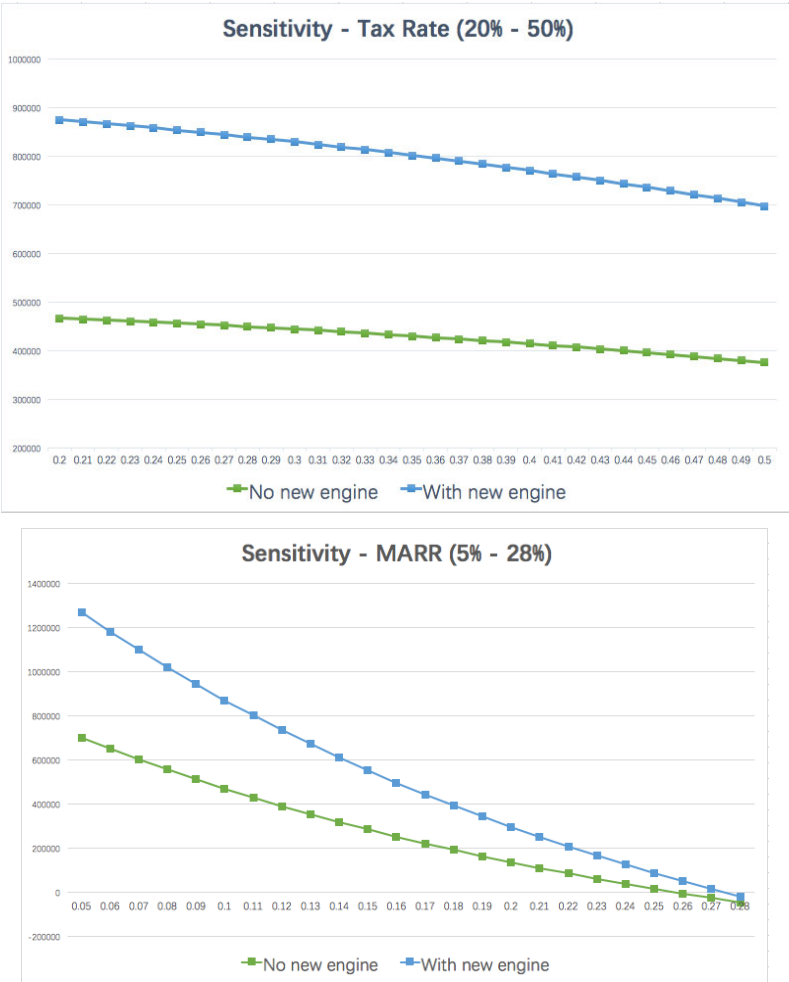
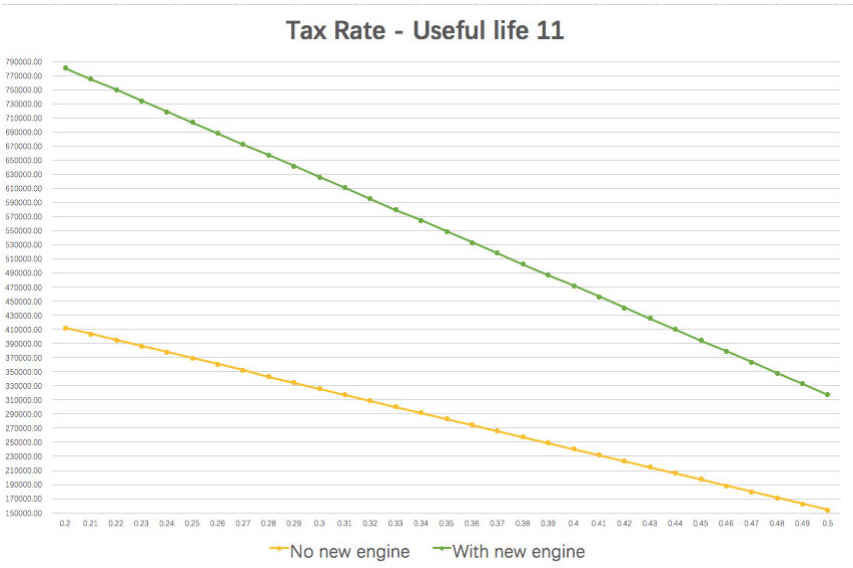


Figure 1.4 Sensitivity (useful life 10)



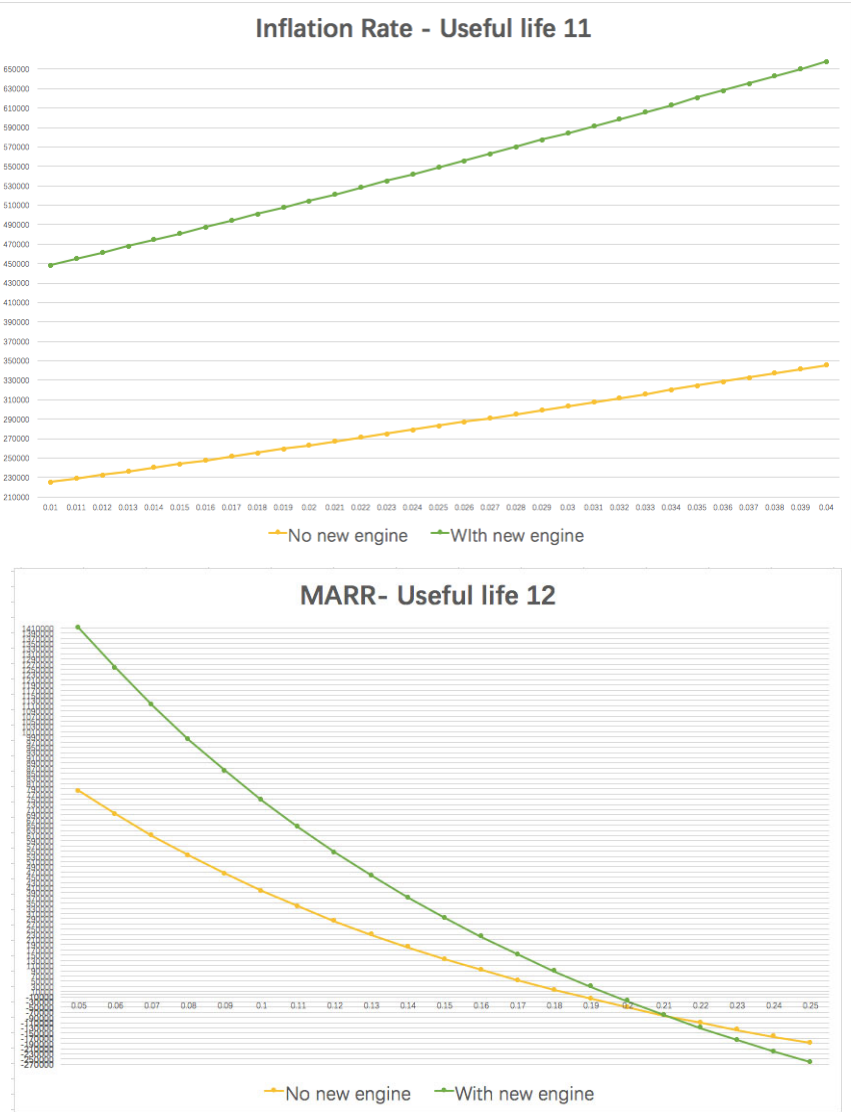


Figure 1.5 Sensitivity (useful life 11)

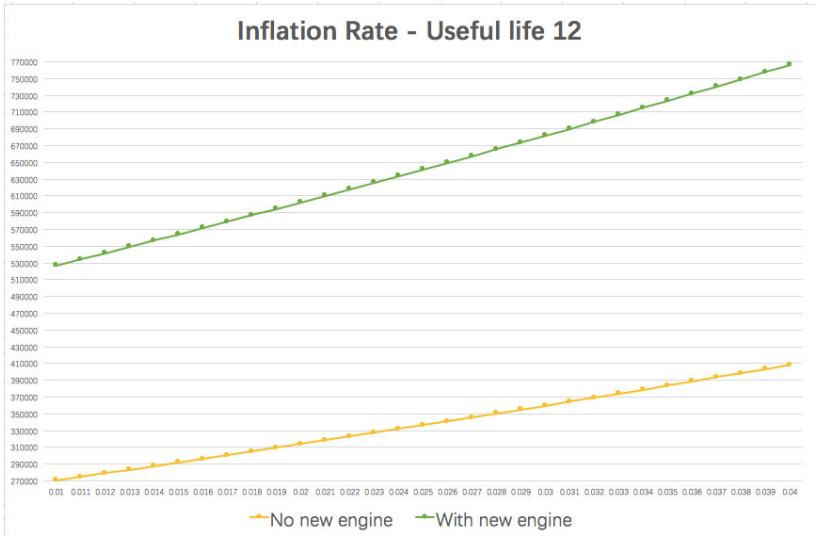




Figure 1.6 Sensitivity (useful life 12)

Table 2.1 ATCF comparison between (a) and (b) (cost only)

Years	1	2	3	4	5	6	7
ATCF in (a)	-820000	-738950	-735181	-765184	-793613	-820881	-847374
ATCF in (b)	-477750	-400631	-453172	-498521	-538158	-573458	-598339
Years	8	9	10	11	12	13	14
ATCF in (a)	-871440	-893696	-916480	-939891	-973243	NULL	NULL
ATCF in (b)	-615016	-632006	-649633	-701929	-754778	-773647	-792988
Years	15	16	17	18	19	20	21
ATCF in (a)	NULL	NULL	NULL	NULL	NULL	NULL	NULL
ATCF in (b)	-812813	-833134	-853962	-875311	-897194	-919624	-942614

Table 2.3: The calculation process of (a) overhauling the Vital Spark

(a) overhauling the Vital Spark												
Year	0	1	2	3	4	5	6	7	8	9	10	11
Initial Outlay	-820000											
Revenue	0	0	0	0	0	0	0	0	0	0	0	0
Operating Costs	1181000	1210525	1240788.125	1271807.828	1303603.024	1336193.099	1369597.927	1403837.875	1438933.822	1474907.168	1511779.847	
Depreciation	82000	147600	118080	94464	75604	60434	53710	53710	53792	53710	26896	
Operatin income before taxes	-1263000	-1358125	-1358868.125	-1366271.828	-1379207.024	-1396627.099	-1423307.927	-1457547.875	-1492725.822	-1528617.168	-1538675.847	
Taxes	-442050	-475343.75	-475603.8438	-478195.1398	-482722.4583	-488819.4848	-498157.7744	-510141.7563	-522454.0377	-535016.0086	-538536.5463	
Operating income after taxes(NOPAT)	-820950	-882781.25	-883264.2813	-888076.6883	-896484.5655	-907807.6146	-925150.1525	-947406.1188	-970271.7843	-993601.1589	-1000139.3	
Add: tax*depreciation	82000	147600	118080	94464	75604	60434	53710	53710	53792	53710	26896	
After tax operating cash flow	-738950	-735181.25	-765184.2813	-793612.6883	-820880.5655	-847373.6146	-871440.1525	-893696.1188	-916479.7843	-939891.1589	-973243.3004	
Total After tax operating cash flows (ACTF)	-820000	-738950	-735181.25	-765184.2813	-793612.6883	-820880.5655	-847373.6146	-871440.1525	-893696.1188	-916479.7843	-939891.1589	-973243.3004
Cost of Capital	11%	1.0715	1.14811225	1.230202276	1.318161739	1.412410303	1.51339764	1.621605571	1.737550369	1.861785221	1.994902864	2.137538419
Present Value @ 11% for Each year (NPV)	-820000	-689640.6906	-640339.1742	-621998.7528	-602060.176	-581191.2897	-559914.7194	-537393.4132	-514342.568	-492258.599	-471146.3279	-455310.3195

Table 2.4: The calculation process of (b) buying the new vessel

(b) buying the new vessel																						
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Initial Outlay	150000																					
Revenue		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Costs		885000	907125	929803.25	953048.031	976874.082	1001296.268	1026328.675	1051986.892	1078286.564	1105243.728	1132874.822	1161196.692	1190226.609	1219982.275	1250481.832	1281743.877	1313787.474	1346632.161	1380297.965	1414805.414	1450175.55
Depreciation		300000	540000	432000	345600	276600	221100	196500	196500	196800	196500	98400	0	0	0	0	0	0	0	0	0	0
Fixed Price		1500000																				
Training		50000																				
Operating income before taxes		2735000	1447125	1361803.125	1298648.203	1253474.408	1222396.268	1222828.675	1248486.892	1275086.564	1301743.728	1231274.822	1161196.692	1190226.609	1219982.275	1250481.832	1281743.877	1313787.474	1346632.161	1380297.965	1414805.414	1450175.55

Taxes (NOPAT)		-957250	506493.74	76631.04	54526.84	38716.04	27838.64	27990.04	36970.44	46280.24	55610.34	43094.87	406418.84	416579.34	426993.74	437668.64	448610.34	459825.64	471321.24	483104.24	495181.84	507561.44	
Operating income after taxes		1777750	940631.28	885172.08	44121.38	814758.37	794557.57	794838.68	11516.48	828806.28	846133.48	800328.67	754777.87	773647.27	792988.48	812813.18	833133.58	853961.88	875310.98	897193.69	919623.59	942614.19	
Add: tax*depreciation		300000	540000	432000	345600	276600	221100	196500	196500	196800	196500	98400	0	0	0	0	0	0	0	0	0	0	
After tax operating cash flow (except the 1st year)		1477750	400631.24	453172.04	498521.35	538158.35	573457.55	598338.66	615016.46	632006.26	649633.47	701928.67	754777.87	773647.27	792988.48	812813.18	833133.58	853961.88	875310.98	897193.69	919623.59	942614.19	
Sale price by selling the vehicle and spare parts		200000																					
Book value of vehicle and spare parts		140000																					
Difference between the sale price and book value of vehicle and spare parts		60000																					
Total After tax operating cash flows		1461000	1477750	400631.25	453172.04	498521.35	538158.35	573457.55	598338.66	615016.46	632006.26	649633.47	701928.67	754777.87	773647.27	792988.48	812813.18	833133.58	853961.88	875310.98	897193.69	919623.59	942614.19
Cost of Capital	11%	1.0715	1.1481121	1.2302021	1.3181611	1.4124101	1.5133971	1.6216051	1.7375501	1.8617851	1.9949022	2.1375382	2.2903722	2.4541342	2.6296042	2.8176213	3.0190813	3.2349453	3.4662443	3.7140803	3.9796374	4.2641814	
Present Value @ 11% for Each year		1461000	1379141	348947.83	368371.93	378194.33	381021.23	378920.63	368979.13	353956.03	339462.53	325646.63	328381.73	329543.73	315242.43	301561.82	288474.92	275955.92	263980.22	252524.32	241565.42	231082.22	221053.92

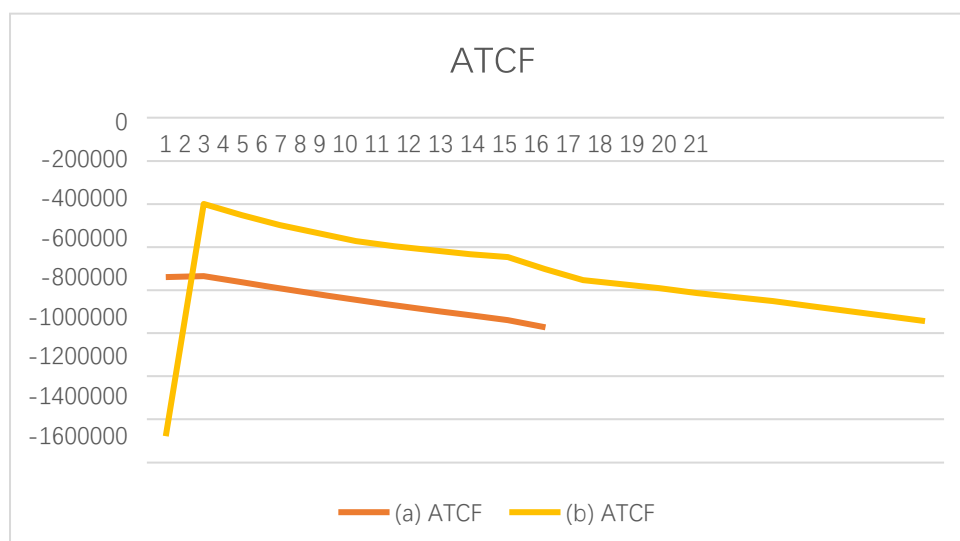


Figure 2.1 ATCF comparison between (a) and (b) (cost only)

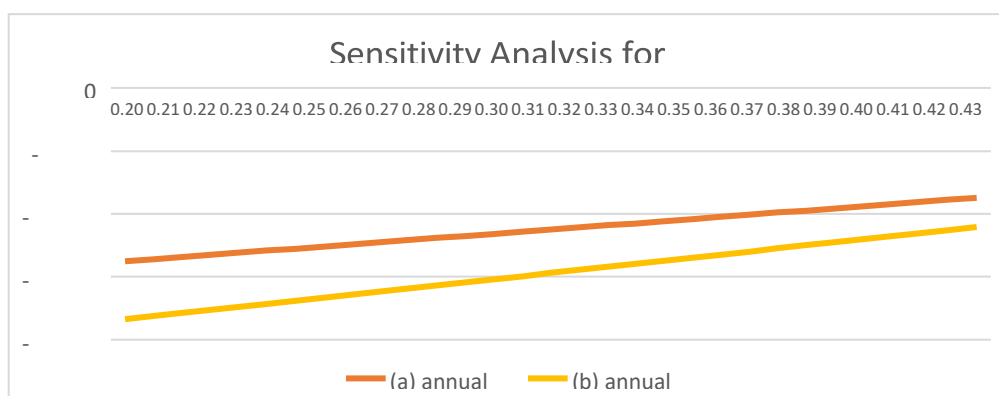


Figure 2.2: Sensitivity Analysis for tax rate (cost only)

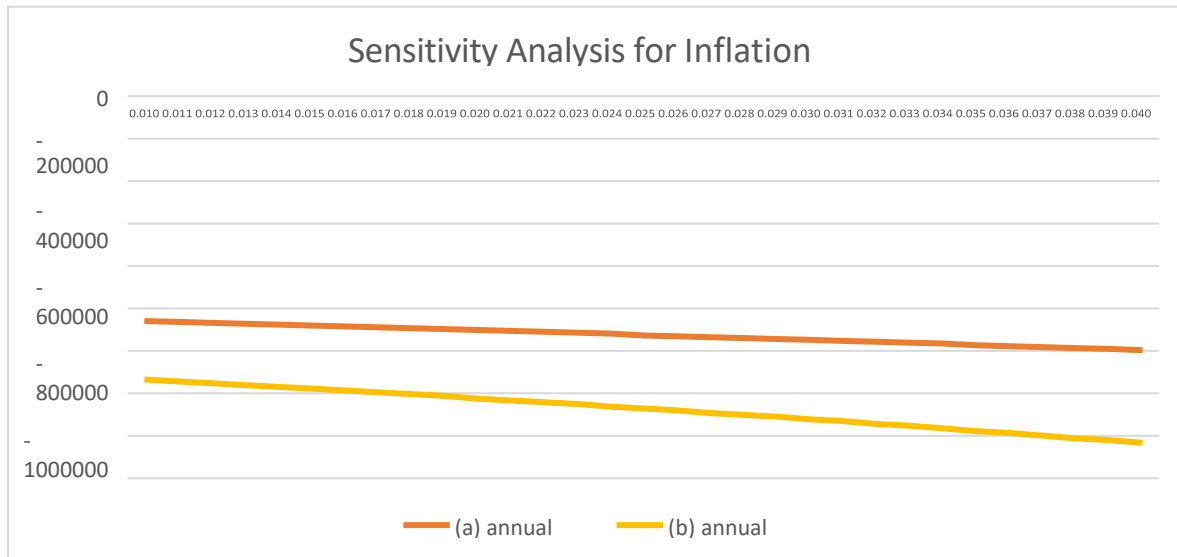


Figure 2.3: Sensitivity Analysis for inflation rate (cost only)

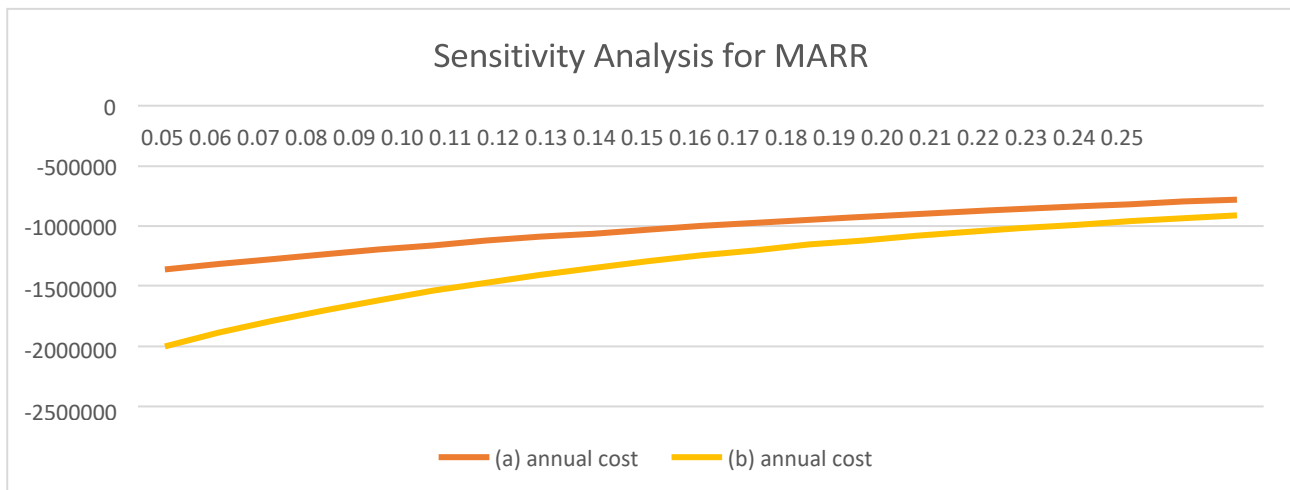


Figure 2.4: Sensitivity Analysis for MARR (cost only)

Table 3.2 The calculation process of (a) overhauling the Vital Spark considering the revenue

(b) buying the new vessel												
Year	0	1	2	3	4	5	6	7	8	9	10	11
Initial Outlay	-820000											
Revenue	0	1400000	1435000	1470875	1507646.875	1545338.047	1583971.498	1623570.785	1664160.055	1705764.057	1748408.158	1792118.362
Operating Costs	0	-1181000	-1210525	-1240788.125	-1271807.828	-1303603.024	-1336193.099	-1369597.927	-1403837.875	-1438933.822	-1474907.168	-1511779.847
Depreciation	0	92000	165600	132480	105984	84824	67804	60260	60260	60352	60260	30176
Book Value	920000	828000	662400	529920	423936	339112	271308	211048	150788	90436	30176	0
Training												
Taxable Income	0	127000	58875	97606.875	129855.0469	156911.023	179974.3986	193712.8586	200062.1801	206478.2346	213240.9904	250162.5152
Taxes	0	-44450	-20606.25	-34162.40625	-45449.26641	-54918.85807	-62991.03952	-67799.50051	-70021.76302	-72267.38209	-74634.34665	-87556.88031
ATCF	-820000	174550	203868.75	195924.4688	190389.7805	186816.165	184787.3591	186173.3581	190300.417	194562.8525	198866.6438	192781.6349
NOPAT		82550	38268.75	63444.46875	84405.78047	101992.165	116983.3591	125913.3581	130040.417	134210.8525	138606.6438	162605.6349
EVA		16770	-20933.25	16082.86875	46516.50047	71680.74098	92736.8511	106514.8361	114950.485	123429.5105	132140.4698	160448.0509
P/F		1.0715	1.14811225	1.230202276	1.318161739	1.412410303	1.51339764	1.621605571	1.737550369	1.861785221	1.994902864	2.137538419
NPV ATCF	-820000	162902.4732	177568.6567	159261.995	144435.8267	132267.6312	122100.996	114808.0405	109522.2449	104503.3822	99687.38197	90188.61752

Table 3.3: The calculation process of (b) buying the new vessel

(a) overhauling the Vital Spark

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Initial Outlay	-1500000																					
Revenue	200000	1500000	1537500	1575937.5	1615335.938	1655719.336	1697112.319	1739540.127	1783028.631	1827604.346	1873294.455	1920126.816	1968129.987	2017333.236	2067766.567	2119460.731	2172447.25	2226758.431	2282427.392	2339488.077	2397975.278	2457924.66
Operating Costs	0	-885000	-907125	929803.125	953048.2031	976874.4082	1001296.268	1026328.675	1051986.892	1078286.564	1105243.728	1132874.822	1161196.692	1190226.609	1219982.275	1250481.832	1281743.877	1313787.474	1346632.161	1380297.965	1414805.414	1450175.55
Depreciation	0	300000	540000	432000	345600	276600	221100	196500	196500	196800	196500	98400										
Book Value	300000	2700000	2160000	1728000	1382400	1105800	884700	688200	491700	294900	98400	0										
Training		-50000																				
Taxable Income	60000	265000	90375	214134.375	316687.344	402244.977	474716.0509	516711.4522	534541.7385	552517.782	571550.7265	688851.9947	806933.2945	827106.6269	847784.2926	868978.8999	890703.3724	912970.99567	935795.2306	959190.1114	983169.8642	1007749.111
Taxes	-14400	-92750	-31631.25	-74947.03125	-110840.707	-140785.7247	-166150.6178	-180849.0083	-187089.6085	-193381.2237	-200042.7543	-241098.1981	-282426.6531	-289487.3194	-296724.5024	-304142.615	-311746.803	-319539.8348	-327528.3307	-335716.539	-344109.4525	-352712.1888
ACTF	-1314400	-1027750	598743.75	571187.3438	551447.0273	538059.2503	529665.4331	532362.439	543952.13	555936.583	568007.9722	546153.7965	524506.65415	537619.3075	551059.7902	564836.2849	578957.1921	593431.1219	608266.8999	623473.5724	639060.4117	655036.922
NOPAT		172250	58743.75	139187.3438	205847.0273	261459.203	308565.4331	335862.439	347452.13	359136.583	371507.9722	447753.7965	524506.65415	537619.3075	551059.7902	564836.2849	578957.1921	593431.1219	608266.8999	623473.5724	639060.4117	655036.922
EVA		-42250	134306.25	15252.65625	82295.02734	162617.6203	222950.7331	272606.3939	298245.83	323980.0083	350422.64222	440718.1965	524506.65415	537619.3075	551059.7902	564836.2849	578957.1921	593431.1219	608266.8999	623473.5724	639060.4117	655036.922
P/F		1.0715	1.148112125	1.230202276	1.318161739	1.412410303	1.51339764	1.621605571	1.737550369	1.861785221	1.994902286	2.137538419	2.290372241	2.454134043	2.629604627	2.817621358	3.019081285	3.234945597	3.466244207	3.714080668	3.979637436	4.264181513
NPV ATCF	-1314400	-959169.3887	521502.7973	464303.5986	418345.4968	380951.0607	349984.3129	328293.4232	313056.8988	298604.0238	284729.639	255505.9557	229004.9592	219066.8065	209559.9409	200465.6457	191766.0167	183443.9264	175482.9907	167867.5366	160582.5712	153613.7522

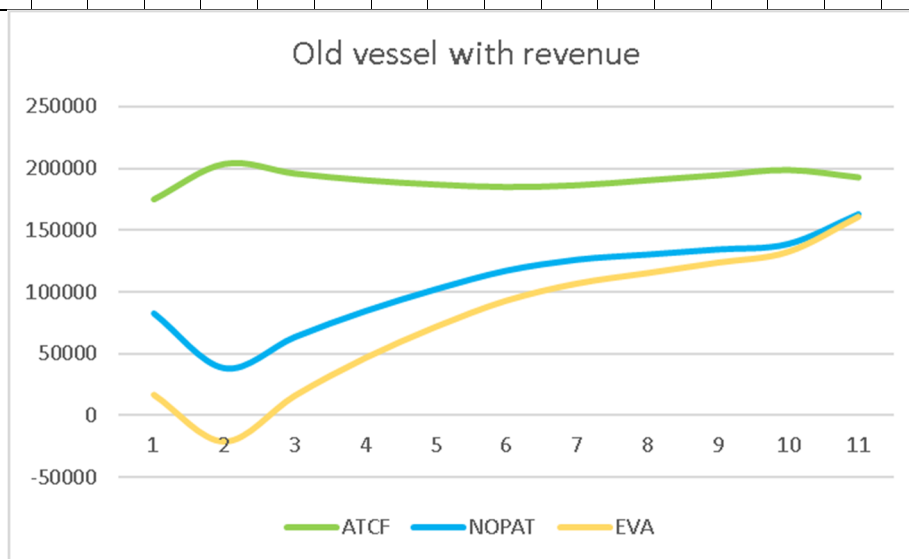


Figure 3.1 ATCF, NOPAT, EVA for overhauling the Vital Spark

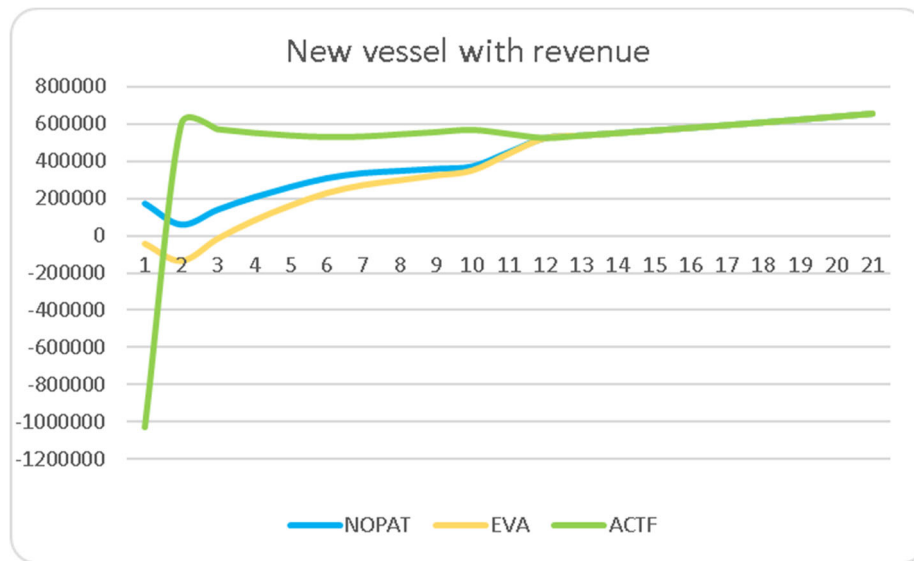


Figure 3.2 ATCF, NOPAT, EVA for buying the new vessel

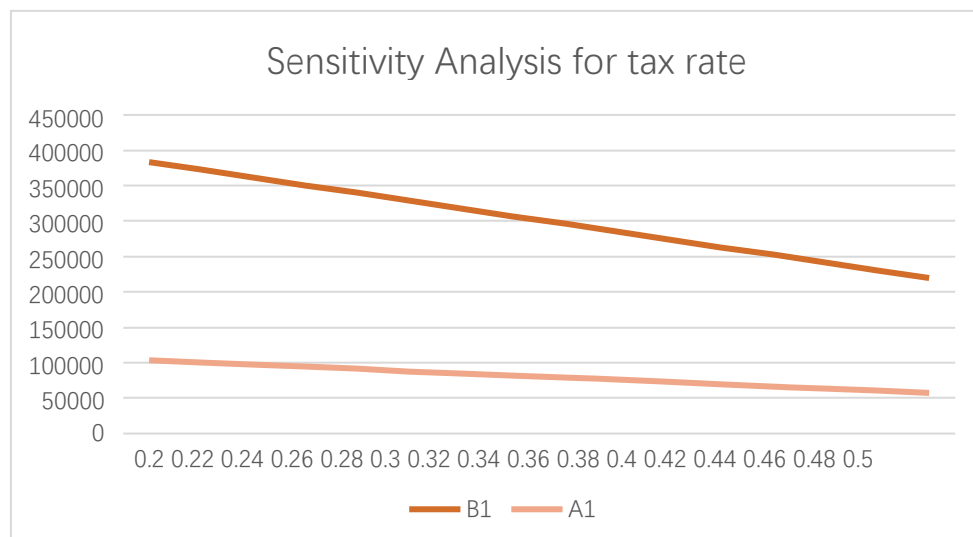


Figure 3.3: Sensitivity Analysis for tax rate (considering revenue)

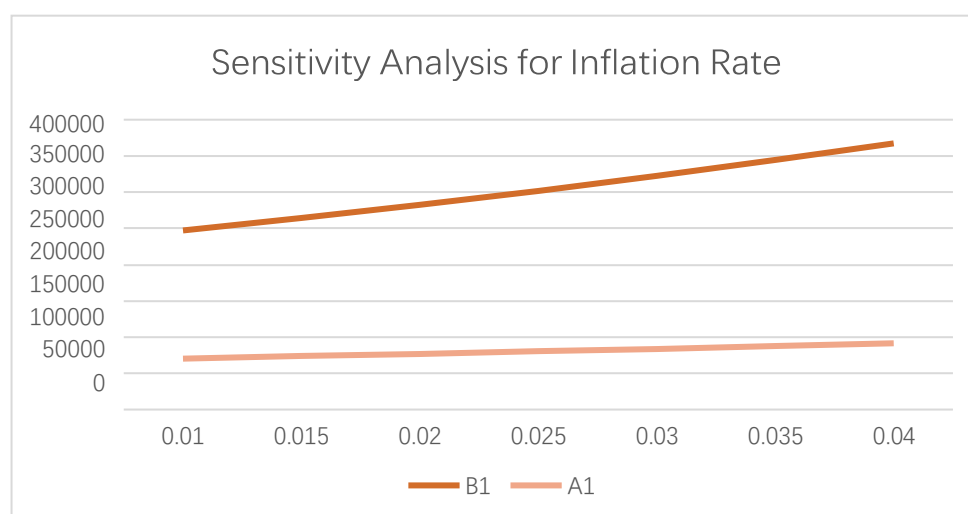


Figure 3.4: Sensitivity Analysis for inflation rate (considering revenue)

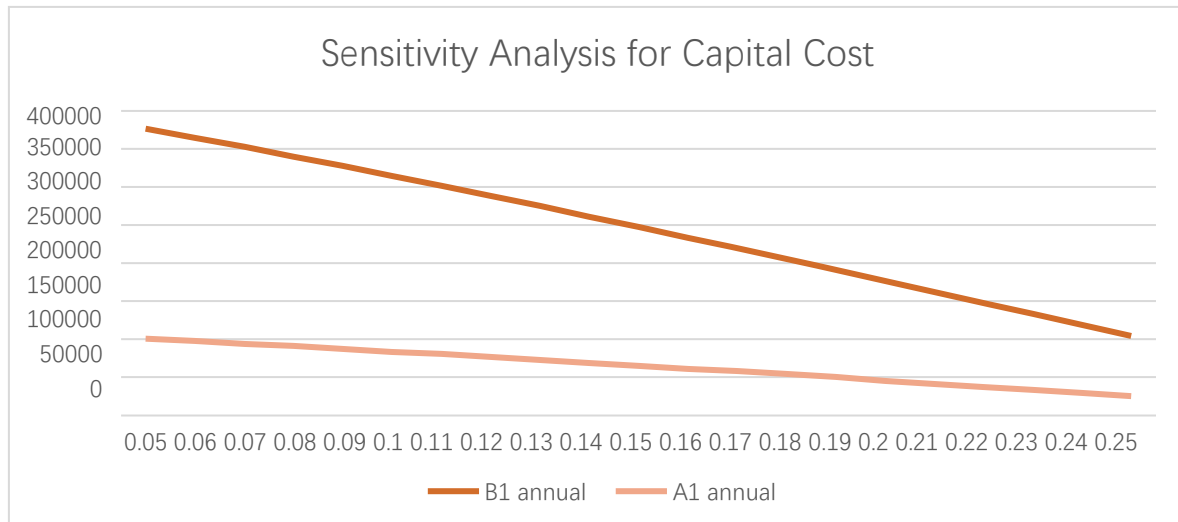


Figure 3.5: Sensitivity Analysis for MARR (considering revenue)

Table 4.2: The calculation process of extension

Computation of total ATCF based on the months left													
Months left	Monthly revenue	Revenue	Monthly cost	Cost	Monthly depreciation	Depreciation Reduction	BTCF	Taxable income	Income taxes	ATCF	Initial BV	Income from scrap	Total cashflow
1	113821.00	113821.00	96016.00	96016.00	5061.00	5061.00	17805.00	12744.00	4460.40	13344.60	100000.00	94939.00	108283.60
2	113821.00	227642.00	96016.00	192032.00	5061.00	10122.00	35610.00	25488.00	8920.80	26689.20	100000.00	89878.00	116567.20
3	113821.00	341463.00	96016.00	288048.00	5061.00	15183.00	53415.00	38232.00	13381.20	40033.80	100000.00	84817.00	124850.80
4	113821.00	455284.00	96016.00	384064.00	5061.00	20244.00	71220.00	50976.00	17841.60	53378.40	100000.00	79756.00	133134.40
5	113821.00	569105.00	96016.00	480080.00	5061.00	25305.00	89025.00	63720.00	22302.00	66723.00	100000.00	74695.00	141418.00
6	113821.00	682926.00	96016.00	576096.00	5061.00	30366.00	106830.00	76464.00	26762.40	80067.60	100000.00	69634.00	149701.60
7	113821.00	796747.00	96016.00	672112.00	5061.00	35427.00	124635.00	89208.00	31222.80	93412.20	100000.00	64573.00	157985.20
8	113821.00	910568.00	96016.00	768128.00	5061.00	40488.00	142440.00	101952.00	35683.20	106756.80	100000.00	59512.00	166268.80
9	113821.00	1024389.00	96016.00	864144.00	5061.00	45549.00	160245.00	114696.00	40143.60	120101.40	100000.00	54451.00	174552.40
10	113821.00	1138210.00	96016.00	960160.00	5061.00	50610.00	178050.00	127440.00	44604.00	133446.00	100000.00	49390.00	182836.00
11	113821.00	1252031.00	96016.00	1056176.00	5061.00	55671.00	195855.00	140184.00	49064.40	146790.60	100000.00	44329.00	191119.60
12	113821.00	1365852.00	96016.00	1152192.00	5061.00	60732.00	213660.00	152928.00	53524.80	160135.20	100000.00	39268.00	199403.20