

Risk Assessment in Financial Feasibility of Tanker Project Using Monte Carlo Simulation

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Abstract— every ship project would not be apart from risk and uncertainty issues. The inappropriate risk assessment process would have long-term impact, such as financial loss. Thus, risk and uncertainties analysis would be a very important process in financial feasibility determination of the project. This study analyzes the financial feasibility of 17,500 LTDW tanker project. Risk and uncertainty are two differentiated terminologies in this study, where risk focuses on operational risk due to shipbuilding process nonconformity to shipowner finance, while uncertainty focuses on variable costs that affect project cash flows. There are three funding scenarios in this study, where the percentage of funding with own capital and bank loan in scenario 1 is 100% : 0%, scenario 2 is 75% : 25%, and scenario 3 is 50% : 50%. Monte Carlo simulation method was applied to simulate the acceptance criteria, such as net present value (NPV), internal rate of return (IRR), payback period (PP), and profitability index (PI). The results of simulation show that 17,500 LTDW tanker project funding by scenario 1, 2 and 3 are feasible to run, where probability of each acceptance criteria was greater than 50%. Charter rate being the most sensitive uncertainty over project's financial feasibility parameters.

Keywords— financial feasibility, monte carlo simulation, risk event, tanker, uncertainty.

I. INTRODUCTION

Tanker is one of vessel types that is very important in the transportation of crude oil or product oil in the world. More than 50% of the world's oil movement use tankers through the sea. This can be observed through the map of global oil movement. It is noted that Hormuz Strait has approximately 17 million barrels oil movement per day and Malacca Strait has approximately 15.2 million barrels oil movement per day [1]. Even, 46% of the vessels passing through Malacca Strait are tankers [2]. Nevertheless, it turns out the existence of tankers has not been able to keep up with the crude oil demand globally [3]. Knowing this condition, the existence of tankers still needed to support the global oil movement.

However, determining the decision of tankers investment requires a detailed risk assessment process. Risk and uncertainties in capital cost, operating cost, bunker cost, freight rate, regulation and safety factors may be encountered during the project [4]. According to research, the consequences of regulatory changes in the maritime can causes financial impact about 5% of operational costs on tankers [5]. In addition, the uncertainty of material cost fluctuations also give financial impact in the chemical tanker building project (30,000 DWT). 75-80% of capital costs should be allocated for anticipate it. Although, by estimating the project's uncertainties, that costs could be reduce about 9% [6].

The fuel cost uncertainty is a considerable cost. The percentage of this cost is up to 58% of the total cost [7]. In recent years, fuel prices have continued to rise along

with fluctuations in crude oil prices. Moreover tankers with voyage charter system still face the risk of a considerable fuel price [8]. This means that the uncertainty of fuel prices is still quite worrying.

The other research explain that delay on delivery until 74 days of tanker building project was categorise on high risk. The engineering, procurement and production stage predicted to cause delays on tanker delivery with probability 0.334 in the ship building industry sub-cluster Surabaya [9]. Thus, the assessment to analyze risks and uncertainties becomes important process in financial feasibility determination of tanker investment decisions.

Project financial feasibility would involve the calculation of some acceptance criteria, such as net present value (NPV), internal rate of return (IRR), payback period (PP), and profitability index (PI). By simulation method, the acceptance criteria is going to be generated as PDFs and CDFs.

Basically, investment decisions can be made by a commonly used deterministic method. However, the deterministic method proved to have weaknesses in predicting the conditions to come. In a deterministic method, cash flow was constructed based on the input of certain estimation values, when in fact they are an uncertainty that may be of different value in the future. As much as possible can be done is to make the values of uncertainty in a certain probability distribution [10] [11].

On the other hand, the simulation method is a method that can accommodate the assessment of risk and uncertainty quantitatively in the determination of project investment [12]. Monte Carlo simulation is one of the most applicable methods. This method is based on the iteration of repeating random numbers and is usually used to get a specific probability model forecast in solving a problem [13]. Thus Monte Carlo simulations can be applied to predict the financial feasibility of the project by considering risks and uncertainties.

Simulation steps for risk analysis in project financial feasibility based on the Monte Carlo simulation technique are as follows: define a quantitative model for the project investment considering all relevant input

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variables; estimate the probability density functions (PDFs) of every input variables; determine correlations cummulative distribution function (CDF) of the output variables (acceptance criteria); then statistical analysis and interpretation of the simulation result [14][30].

This study would discuss the financial feasibility of a 17,500 LTDW tanker project owned PT. Pertamina (Persero) Shipping by considering the risk and uncertainty based on the ship owner's point of view. This paper is grouped into four main sections. First, introduction that explains the background why this topic is worth to discuss. Second, the method that describes the stages to perform the analysis. Third, explains the result and discussion of the analysis. Fourth, explains the conclusion.

II. METHOD

The process in this study is shown in Figure 1. Risk events and uncertainty variables is being separated first. Risk events will be analyzed by probability and impact analysis, then represented in risk matrix. Uncertainty variables will be distributed by a certain PDFs, then formed as input to the cash flow of the tanker project. Monte Carlo simulation would be applied to obtain each probability of NPV>0, IRR>7.83%, PP<20 years and PI>1. Simulation is done to get CDFs of the acceptance criterias. Sensitivity analysis was done after simulation.

A. Risk Identification

Generally, the risk will occur if there is source and cause of risk and result in certain impact. Source of risk is inherent from within the system. While the cause of risk is a risk factor that is usually caused by external factors. How often these causes of risk occur can be analyzed by probability analysis. The impact of risk will arise when risk occurs, where risk is caused by a combination of source of risk with a cause of risk [15].

This study focuses on assessing operational risk aspects during shipbuilding process where it could affect the ship owner's financial condition when it occurs. In addition, potential cause of risk occurs also identified in this stage. The major potential causes of this risk obtained by interviews to Planning and Controlling

between the input variables; calculate the PDF and

Department of PT. X shipyard.

B. Probability Analysis

Basically the probability calculation of an event in a system is done by various methods with different precision levels. But for more complex systems with more items, then by applying theoretical probability calculation method will be quite time consuming and exhausting. Thus the calculation through the approach method can be applied to speed up the completion. Although the precision level is lower, the calculation results with the approach still gives the error rate within acceptable limits [16]. This stage is aimed to determine probability value (*P*) of each risk event by Upper Bound and Lower Bound approach.

If C_i is a minimum cut set and $P(C_i)$ is the probability of C_i , so the failure probability of system by using Upper Bound and Lower Bound approach are given by the formula in Eqs (1) and (2).

$$Q_{S \text{ Upper bound}} = \sum_{i=1}^n P(C_i) \quad (1)$$

$$Q_{S \text{ Lower bound}} = \sum_{i=1}^n P(C_i) - \sum_{i=2}^n \sum_{j=1}^{i-1} P(C_i \cap C_j) \quad (2)$$

where, C_i is a minimum cut set and $P(C_i)$ is the probability of C_i given by $P(C_i) = Q_1 \cdot Q_2 \cdot \dots \cdot Q_n$ where Q_n is the failure probability of the item *n* and Q_S is failure probability of the system.

In this case, to define the probability of potential cause could be calculated from activities percentage of Work Breakdown Structure (WBS) of the new shipbuilding project.

C. Impact Analysis

Financial impact estimated in three point estimates, that are minimum (Min), most likely (ML), and maximum (Max) with an impact margin scenario. The impact rating shown in Table 1, where BTR is the risk tolerance limit, taken 5% of CAPEX.

TABLE 1.
 FINANCIAL IMPACT RATING (PT. PERTAMINA (PERSERO) SHIPPING)

Financial impact range	Impact rating	Level
0 – 20% BTR	1	Insignificant
21 – 40% BTR	2	Minor
41 – 60% BTR	3	Moderate
61 – 80% BTR	4	Significant
81 – 100% BTR	5	Catastrophic

D. Risk Reprerentation at Risk Matrix

Risk value is known by multiplying probability (P) and impact (I), i.e. risk score = $P \times I$. Then, risk score is represented at the risk matrix. Based on the risk matrix representation, the level of each risk (very low, low, medium, high, very high) can be known. If the risks are in unacceptable category, avoidance, mitigation, or risk transfer is necessary.

E. PDF Determination of Probability and Impact

Probability values will be distributed using bernoulli distribution as Eqs (3), whereas impact will be distributed using triangular distribution as Eqs (4) [11] [17]. For the reason, that probability value would only give possibility of occurrence, it is perceived that bernoulli distribution is appropriate to be applied. While impact value are estimated in three point estimates, where the ML value lies between the Min and Max

values, so impact was estimated using triangular distribution.

$$f(x) = \begin{cases} 1 - p & \text{for } x = 0 \\ p & \text{for } x = 1 \end{cases} \quad (3)$$

where, p is the mean value.

$$f(x) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)}, & a \leq x \leq c \\ \frac{2(b-x)}{(b-a)(b-c)}, & c < x \leq b \end{cases} \quad (4)$$

where, a , b and c denote the minimum, maximum and most likely values, and p is the success probability of system.

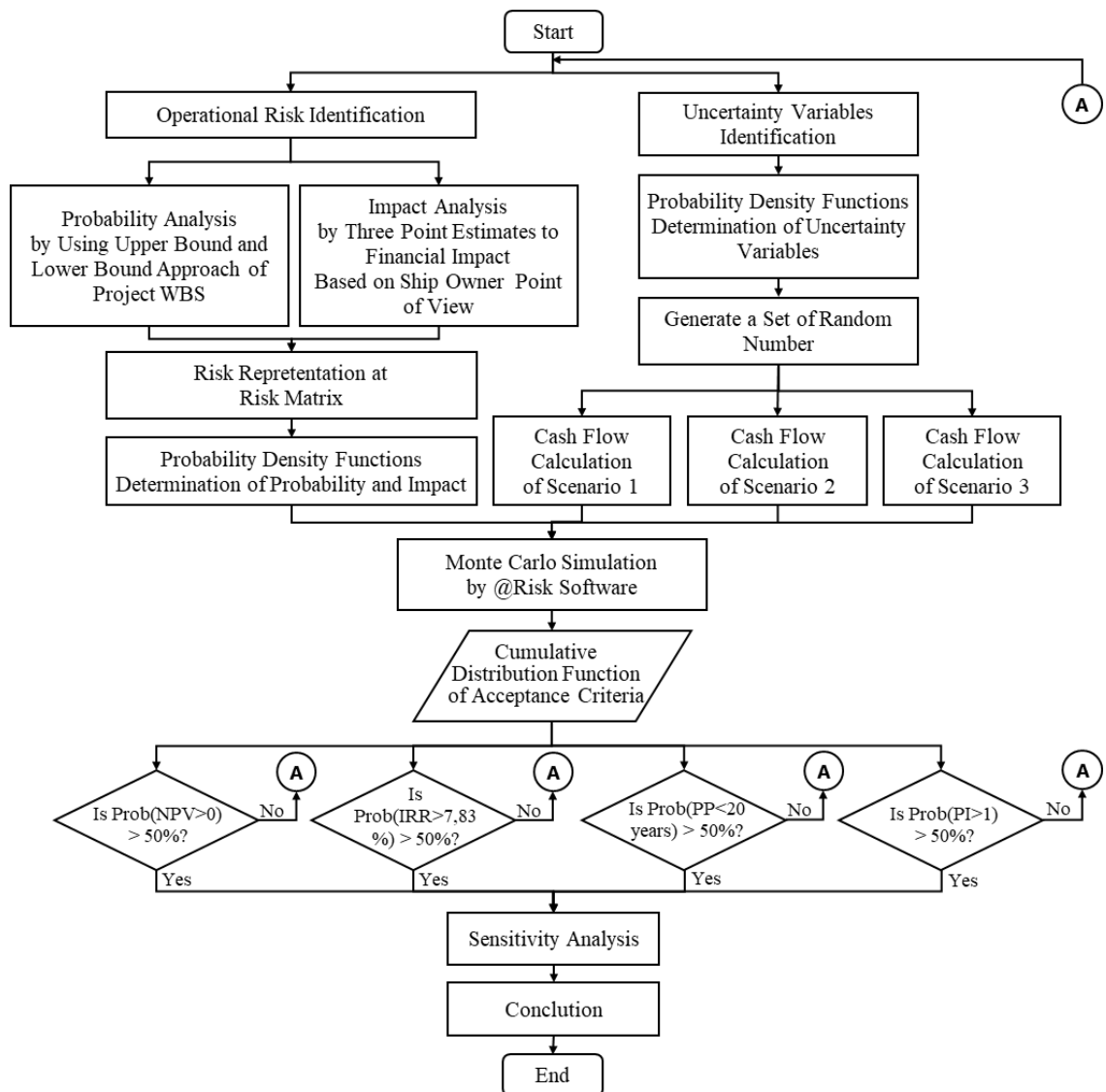


Figure 1. Research Methodology

F. Uncertainty Variable Identification

The purpose of this stage is to determine uncertainty variables that are expected to be highly volatile over the life of the project investment in this case study. The uncertain variables mean as input factors to the cash flow of project. Assuming that the tanker would be functioned

for voyage charters, so the cost variable that will affect the ship owner are like capital cost, operational cost, voyage cost, and periodic maintenance cost. The cargo handling cost is borne by the charterer [7].

G. PDF Determination of Uncertainty Variable

In general, PDF determination could be done by three approaches, those are real data distribution, empirical distribution and theoretical distribution function. The first approach could be done if there are large amounts of data. It will consuming extremely time, properly it is very hard to be realized. The second approach is obtained by grouping the real data to frequency histogram into a simulation model. However, incomplete data cause it so difficult. In contrast, a theoretical distribution function using heuristic procedures will take extreme values into account and timesaving procedure in performing simulations [18]. So, the last approach is commonly used.

The most commonly used PDFs for quantitative risk analysis in project management and finance term are uniform distribution, lognormal, bernoulli distribution and triangular distribution [11]. The PDF of uniform and lognormal distribution is described as Eqs (5) and Eqs (6) [17].

$$f(x) = \frac{1}{b-a} \tag{5}$$

$$f(x) = \frac{1}{x\sqrt{2\pi}\ln(\sigma)} e^{-\frac{[\ln(x)-\ln(\mu)]^2}{2[\ln(\sigma)]^2}} \tag{6}$$

where, a and b denote the minimum and maximum values, μ is mean and σ is standard deviation.

H. Generate a Set of Random Number

Random numbers are obtained by various sampling method, for example by random number table in general literature or by simulation software. The most important matter is the randomness of these numbers must be guaranteed. In this case, the help of simulation software by Monte Carlo sampling to get random number was applied.

I. Cash Flow Calculation

The cash flow is divided into four parts, namely the initial, operational, terminal, and net cash flow. The initial cash flow would be related to the CAPEX. The operational cash flow would be related to earning, OPEX, depreciation, Earning Before Interest Tax Depreciation and Amortation (EBITDA), tax, and Earning After Tax (EAT). Terminal cash flow would be related to the salvage value of the asset (usually considered as zero salvage value). While net cash flow would be related to loan repayment, discount factor, discounted cash flow and cumulative discounted cash flow [19][31].

OPEX variables are usually the most important to be considered. This is divided into three categories, i.e. operational costs and voyage costs which is described in Eqs (6) and (7), and periodic maintenance cost [7].

$$OC_{tm} = M_{tm} + ST_{tm} + MN_{tm} + I_{tm} + AD_{tm} \tag{6}$$

where, OC_{tm} is operating cost, M_{tm} is manning cost, ST_{tm} is stores and consumable cost, MN_{tm} is routine maintenance cost, I_{tm} is insurance cost and AD_{tm} is administration cost.

$$VC_{tm} = FC_{tm} + PD_{tm} + TP_{tm} \tag{7}$$

where, VC_{tm} is voyage cost, FC_{tm} is fuel cost for main engine and auxiliary engine, PD_{tm} is port and light dues cost, and TP_{tm} is tug and pilotage cost.

In operation, the ship's fuel consumption depends on its hull condition and the speed at which it is operated. Operation of the vessel at lower speeds results in fuel savings because of the reduced water resistance. Fuel consumption could be calculate by Eqs (8).

$$F = F^* \left(\frac{S}{S^*}\right)^a \tag{8}$$

where, F is the actual fuel consumption (tons/day), S the actual speed, F^* the design fuel consumption and S^* the design speed. The exponent a has a value of about 3 for diesel engines and about 2 for steam turbines.

The acceptance criteria, such as NPV, IRR, PP and PI calculated by the Eqs (9), Eqs (10), Eqs (11) and Eqs (12). Project will be accepted if the value of NPV greater than 0, IRR greater than 7.83%, PP less than 20 years and PI greater than 1.

$$NPV = \sum_{t=0}^n \frac{(CF)_t}{(1+i)^t} - \sum_{t=0}^n \frac{(Co)_t}{(1+i)^t} \tag{9}$$

$$\sum_{t=0}^n \frac{(CF)_t}{(1+i)^t} - \sum_{t=0}^n \frac{(Co)_t}{(1+i)^t} = 0 \tag{10}$$

$$\sum_{t=0}^n \frac{(CF)_t}{(1+i)^t} - (Cf) = 0 \tag{11}$$

$$PI = \frac{\sum_{t=0}^n \frac{(CF)_t}{(1+i)^t}}{\sum_{t=0}^n \frac{(Co)_t}{(1+i)^t}} \tag{12}$$

where, n is tanker economic life time, t is year, CF is cash inflow, Co is cash outflow, Cf is initial cost and i is rate of return.

J. Monte Carlo Simulation

This simulation stage requires help from @Risk software. The simulation would be run up to 5,000 iterations with expected to get a model that is close to real conditions. The result from this simulation is CDF of each acceptance criteria. The probability of success of the acceptance criteria in the 50% to 100% range can be used as a reference in considering the feasibility of the project. This value is at a very likely level of certainty as shown in Table 2 [20]. If probability of acceptance criteria less than 50%, project is not feasible. The literature review that apply the Monte Carlo simulation method in financial feasibility of project shown in Table 3.

TABLE 2.
 A WAY TO STRUCTURE PROBABILITY OF OCCURRENCE

Degree of certainty	Probability
Not likely	< 5%
Less likely	5% - 20%
Likely	20% - 50%
Very likely	50% - 100%

TABLE 3.
 LITERATURE REVIEW THAT APPLY THE MONTE CARLO SIMULATION METHOD IN FINANCIAL FEASIBILITY

No.	Authors	Result
1.	(Liu, et al., 2017)	Monte Carlo simulation could estimate the financial feasibility of oil refinery project in Brazil. The probability of NPV>0, before and after tax were 54.1% and 51.4%. Probability of IRR>13%, before and after tax were 88.1% and 82.8%.
2.	(Chu, et al., 2016)	Monte Carlo simulations could be applied in the finance analyzing of Hydroprocessed Renewable Jet fuel production with probability of IRR>15% were 29%, 18%, 8%, and the probability of NPV>0 were 85%, 75%, 58% respectively for camelina, carinata and used cooking oil.
3.	(Saffie & Jaaman, 2016)	Monte Carlo used on NPV for capital investment in Malaysia. It was an easy and practical technique that could be used to improve NPV analysis. The results show the estimation of NPV constitute with the uncertainty of the cash flows.
4.	(Amigun, et al., 2011)	Monte Carlo used on economic risk assessment of advanced process technologies for bioethanol production in South Africa. There were three scenario in this research. The result shows probability of NPV>0 were 93%, 98% and 96% for each scenario.

K. Sensitivity Analysis

The sensitivity analysis aims to identify the most important input variables which lead to the greatest decrease of the output variables when it varied, and to reduce the number of unnecessary input variables which will not lead to significant reductions in the uncertainty of the output variables [21]. By knowing the sensitive variables, it will be able to provide input in planning the strategy in running the project.

Sensitivity analysis can be started after the simulation is done. This analysis will involve determining the correlation between input and output variables. The spearman correlation could be use. That is a statistical

measure of the strength of a monotonic relationship between paired data. The calculation of Spearman correlation coefficient is described in Eqs (13).

$$\rho = 1 - \frac{6 \sum (\Delta R)^2}{n(n^2 - 1)} \tag{13}$$

where, ρ is correlation coefficient, ΔR is rank difference between variables, n is count of data.

Correlation is an effect size and verbally describe the strength of the correlation using the following guide in Table 4 for the absolute value of ρ [22].

TABLE 4.
 CORRELATION COEFFICIENTS

Correlation	Negative	Positive
Perfect correlation	-1	1
Significant correlation	-0,75	0,75
Good correlation	-0,5	0,5
Mild correlation	-0,25	0,25
No correlation	0	0

III. RESULTS AND DISCUSSION

This paper focuses on detailing the risk events and uncertainty variables that could affect financial feasibility of 17,500 LTDW tanker project. This part grouped into general assumption, risk analysis, PDF of uncertainty variable, and simulation result.

A. General Assumption

As a support of analysis in this research, the ship sister data was needed as shown in Table 5. In this case, used data of MT. Pagerungan owned PT. Pertamina (Persero) Shipping.

The general assumption for financial feasibility calculation in this paper are:

- 1) Economic life: the economic life of tanker in this case is 20 years of operation, starting from July 2020.
- 2) Design and the construction phase: this paper assumes that the design and the construction phase would be finished for two and half years, starting from January 2018.
- 3) Depreciation method: this paper assumes a straight line depreciation starting from the first year of operation, with a zero salvage value.
- 4) CAPEX payment period: CAPEX payment period to shipyard is divided into three period with percentage are 20%, 40% and 40%.
- 5) Tax: oil company tax is 25%.
- 6) Scenario: there are three scenarios of project financing in this paper. The proportion with private fund and bank loan for each scenario are, first scenario 100% : 0%, second scenario 75% : 25%, and third scenario 50% : 50%.

- 7) Bank interest rate: the bank loan are assumed with compound interest.
- 8) Acceptance criteria: the acceptance criterias of financial feasibility in this paper are NPV>0, IRR>7.83%, PP<20 years and PI>1. Project will feasible if probability of each criteria is greater than 50% based on simulation.
- 9) The vessel will be used for voyage charters where the cost of capital, operational costs and voyage costs are borne by ship owner.
- 10) Shipping route scenario: the ship route scenario is from Tanjung Sekong (Cilegon, Indonesia) - Port of Klang (Malaysia) - Belawan Port (Sumatera, Indonesia).

B. Risk Analysis

Based on risk analysis, the operational risk register in 17,500 LTDW tanker project shown in Table 6. The risk of delays in delivery of new vessels potentially lead to a disruption to the ship's voyage schedule, so that the shipowner must issue a replacement vessel rental fee due to a contract with the charterer. The risk of insufficient speed cause unsuitable of the voyage time. Beside that, lower design speed, will increase the fuel cost. Excessive fuel consumption lead to actual fuel consumption exceeds the design fuel consumption, so that the fuel cost increase. Insufficient dead weight tonnage potentially lead to lower cargo lifting amount. The risk of ships having off hire after delivery cause losses to ship's sailing time due to the time constrained for repair, so that revenue will decrease. The risk representation in risk matrix shown in Figure 2.

TABLE 5.
SHIP SISTER DATA

Item	Unit	Nominal
Ship name	–	MT. Pagerungan (product oil tanker)
Deadweight	LTDW	17,500
L x B x H	m	149.50 x 27.70 x 12.00
Draught	m	7.00
Cont. max. speed	knot	13.39
Service speed	knot	12.5
Cargo capacity	m ³	25,528
Main engine power	kW	4,400
Main engine SFOC	g/kWh	179
Main engine SLOC	g/kWh	0.6
Aux. engine power	kW	2,320
Aux. engine SFOC	g/kWh	185
Aux. engine SLOC	g/kWh	0.6
Number of crew	person	7

TABLE 6.
 RISK REGISTER OF THE TANKER PROJECT

Code	Risk Event	Prob.	Financial Impact (USD)			Risk Level
			Min	ML	Max	
R1	Risk of delays in delivery of new vessel	0.475644	(731,729)	(6,343)	562,984	Very Low
R2	Risk of insufficient speed design	0.009663	247,757	390,208	559,245	Very Low
R3	Risk of excessive fuel consumption	0.012198	112,987	197,343	266,662	Very Low
R4	Risk of insufficient dead weight tonnage (DWT)	0.004492	32,605	150,788	494,325	Very Low
R5	Risk of tanker having off hire after a year delivery	0.014133	30,000	115,000	300,000	Very Low

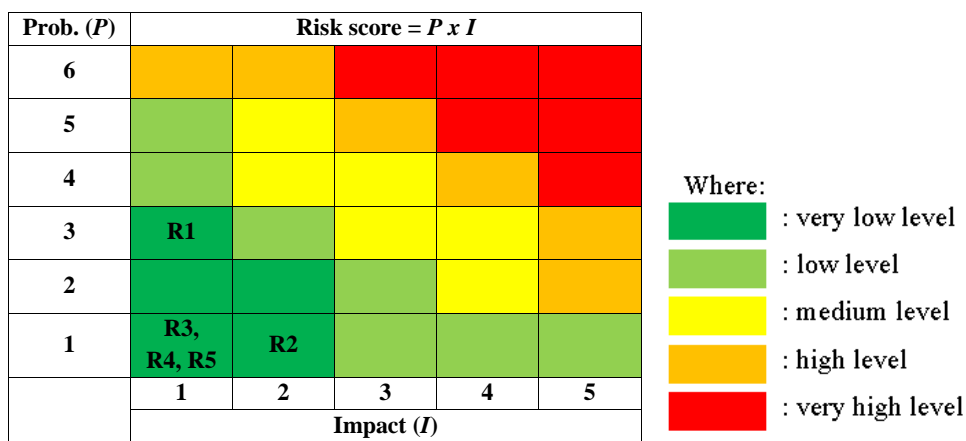


Figure. 2. Risk Representation in Risk Matrix

C. PDF of Uncertainty Variable

The uncertainty variables and its PDFs shown in Table X. The uncertainty variables was estimated in three point estimates, i.e. Min, ML and Max. Some variables could be assumed to be fixed, i.e. ship size is 17,500 LTDW, oil company tax is 25%, vessel investment life time for 20 years and rate of returns (i) is 7.83% [23].

The estimated value of CAPEX is based on PT. Pertamina (Persero) Shipping, ie minimum estimate is 22,676,469 USD, most likely amounted to 23,869,967 USD and maximum of 25,063,465 USD.

Estimated value of OPEX is based on several reference sources. Explanation of each variable cost is as follows:

- 1) Crew costs are the costs incurred for crew salaries, operational and insurance needs. With the number of crew is 7 people and the calculation estimate refers to the Peraturan Menteri Perhubungan No. 3 RI 2017, the most likely estimate for crew costs is 241,672 USD/year with $\pm 5\%$ for min and max estimates.
- 2) Lubricating cost is calculated by referring to the price of lubricant in the range of 4,000 to 5,000

USD/ton and the change of lubricant is done once in a year, the estimated cost for main engine and auxiliary engine lubricant needs is minimum 114,728 USD/year and maximum 143,410 USD/year.

- 3) The cost of repair and maintenance is the estimated cost incurred for the maintenance of the ship (not including periodic maintenance). This cost value is estimated by referring to PT. Pertamina (Persero) Shipping where the cost of repair and maintenance for tanker 17,500 LTDW is 967 USD/year. In this research, minimum and maximum repair and maintenance cost is estimated $\pm 5\%$.
- 4) Insurance costs represent costs incurred for hull and machinery insurance and protection and Indemnity Insurance. Referring to PT. Pertamina (Persero) Shipping where the cost is 55,440 USD/year and 25,907 USD/year, the total cost of insurance is 81,347 USD/year. In this study, the minimum and maximum insurance costs are estimated $\pm 2.5\%$.

TABLE 7.
 PDF AND ESTIMATION VALUE OF UNCERTAINTY VARIABLE

No.	Cost category	Uncertainty variable	Unit	Estimation (USD)			PDF	Note
				Min	ML	Max		
1	CAPEX	Capital Expenditure	USD	22,676,469	23,869,967	25,063,465	Triangular	Estimation (PT. Pertamina (Persero) Shipping)
2.	OPEX	Crew cost	USD/year	229,589	241,672	253,756	Triangular	Estimation (Peraturan Menteri Perhubungan No. 3 RI tahun 2017) ± 5%
		Lubricating cost	USD/year	114,728		143,410	Uniform	Estimation
		Repair & maintenance cost	USD/year	919	967	1,015	Triangular	Estimation (PT. Pertamina (Persero) Shipping) with ± 5%
		Insurance cost	USD/year	79,313	81,347	83,381	Triangular	Estimation (PT. Pertamina (Persero) Shipping) with ± 2.5%
		Administration cost	USD/year	7,600	8,000	8,400	Triangular	Estimation with ± 5%
		Docking cost	USD/dock	530,225	543,820	557,416	Triangular	Estimation (PT. Pertamina (Persero) Shipping) with ± 2.5%
		Fuel cost	USD/year	2,259,731	2,466,793	2,666,619	Triangular	Empiris (Ship & Bunker 21 April 2017; Bunker index MDO 14 Juni 2017)
		Port charges	USD/year	1,034,999	1,040,554	1,046,110	Triangular	(Pelindo I, 2004)
3	Earning	Commissioning day	days/year	326	328	330	Triangular	Estimation
		Charter rate	USD/day	10,000	23,000	30,000	Triangular	Empiris (Sand, P., 2017)
		Bunker cost saving	USD/year	1,040,988	1,136,375	1,228,429	Triangular	Estimation
		Port charges saving	USD/year	17,721	25,315	20,252	Triangular	Estimation
4	Other	Interest rate	% / year	4.75	7.45	12.75	Lognormal	Empiris (Taborda, 2017. Indonesia Interest Rates 2005 – 2017)

- 5) Administration costs are allocated for ship correspondence, where the estimated administration cost is approximately 8,000 USD/year, with minimum and maximum estimates being ± 5%.
- 6) The docking cost is the cost incurred for ship docking, where docking estimates are only made during intermediate surveys and special surveys (2.5 years). The value of this cost is estimated by referring to PT. Pertamina (Persero) Shipping where the docking cost is 543,820 USD/docking. In this study, minimum and maximum docking costs were estimated ± 2.5%.
- 7) Fuel costs are based on the price range of Heavy Fuel Oil (HFO) and Marine Diesel Oil (MDO). Referring to [24] dated 21 April 2017, HFO is within the minimum price range of 303 USD/ton, most likely at 315 USD/ton and a maximum of 323 USD/ton. Whereas with reference to the MDO Bunker index of 14 June 2017, the MDO is in the minimum price range of 434 USD/ton,

most likely at 481 USD/ton and maximum of 528 USD/ton.

By calculating the fuel cost requirements per year, fuel cost are estimated at a minimum value of 2,259,731 USD/year, most likely at 2,466,793 USD/year and a maximum of 2,666,619 USD/year.

- 8) Port costs include mooring, landing, tugboat and guiding services. Referring to Pelindo I data, the estimated port cost is 15,189 USD/at port. The estimated port cost based on the estimated number of visits to the port per year is minimum 1,034,999 USD/year, most likely 1,040,554 USD/year and maximum of 1,046,110 USD/year.

The estimated earnings value is based on the number of commissioning day and charter rate of the vessel. In addition, cost saving estimates also need to be taken into account. Explanation of each variable cost is as follows:

- 1) Commissioning day is the number of days that the ship will earn revenue for shipowners based on

endurance estimates, estimated unwanted off-hire time i.e. 24 days per year [7], the loading and estimated for 30 days each time docking. The time ship is during endurance 7.35 days plus the time at the harbor for 7 days, so the time to take one around trip is 14.35 days/around trip. Minimum commissioning day estimation result is 326 days, most likely is 328 days and maximum is 330 days. Assuming the voyage distance 2,130 Nmiles in once around trip, then the average voyage number is 23 times in a year. So, the estimation of minimum commissioning day is 326 days, most likely is 328 days and the maximum is 330 days.

- 2) Charter rate is the amount of daily charter rate received by the ship owner from the charterer. This value is based on crude oil and product oil tanker earning 2015-2016 data from BIMCO, Clarksons [25], ie minimum estimate is 10,000 USD/day, most likely 23,000 USD/day and maximum 30,000 USD/day.
- 3) Bunkers cost saving is the amount of fuel cost savings resulting from the operation of the ship in a speed that is considered optimum. This value can be calculated by calculating the fuel requirements in some scenarios of ship service speed variation from 13.9 knots to 10 knots. This calculation should also consider earning loss to be smaller than the cost savings. The estimated cost

unloading time of vessels at the port and docking each time for 2.5 years. Time for docking is of the minimum bunker cost saving is 1,040,988 USD/year, most likely at 1,136,375 USD/year and a maximum of 1,228,429 USD / year.

- 4) Port charges saving is the magnitude of port cost savings resulting from the operation of the vessel at a speed that is considered optimum. This value is obtained by the same calculation as bunker cost saving. Estimated port charges saving minimum is 17,721 USD/year, most likely 20,252 USD/year and maximum 25,315 USD/year.

Because in calculations using bank loan scenarios, so the interest rate is also estimated. Interest rate or interest rate of bank which is estimated with reference to data of interest rate value from Bank Indonesia. Interest rate from 2005 to 2017 stated that the minimum value of 4.75% and maximum 12.75% with an average of 7.45% [26].

D. Simulations Result

The previous calculation states that scenario 1 is worth choosing. However, how well the probability of success of each scenario when executed is unknown. Therefore, to know its, Monte Carlo simulation was then adopted to obtain the CDFs of NPV, IRR, PP and PI. In order to achieve mean and variance stability, number of iterations was set at 10,000.

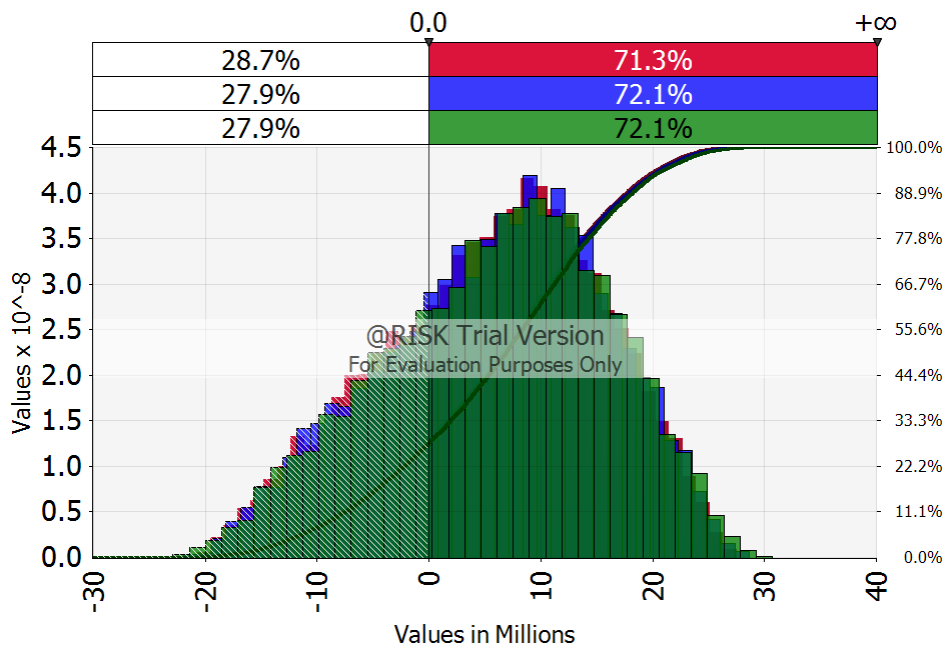


Figure 3. Cumulative Distribution Functions of NPV

TABLE 8.
 STATISTIC DATA FROM NPV SIMULATION RESULT

Statistic	Value		
	Scenario 1	Scenario 2	Scenario 3
Mean	5,629,700	5,805,205	5,981,896
Median	6,555,222	6,686,650	6,917,720
Standard deviation	9,814,970	9,899,055	10,043,528
Skewness	-0.274	-0.275	-0.278
Kurtosis	2.407	2.413	2.465
Minimum	-20,778,700	-21,937,752	-27,235,132
Maximum	27,543,758	28,604,553	30,703,607

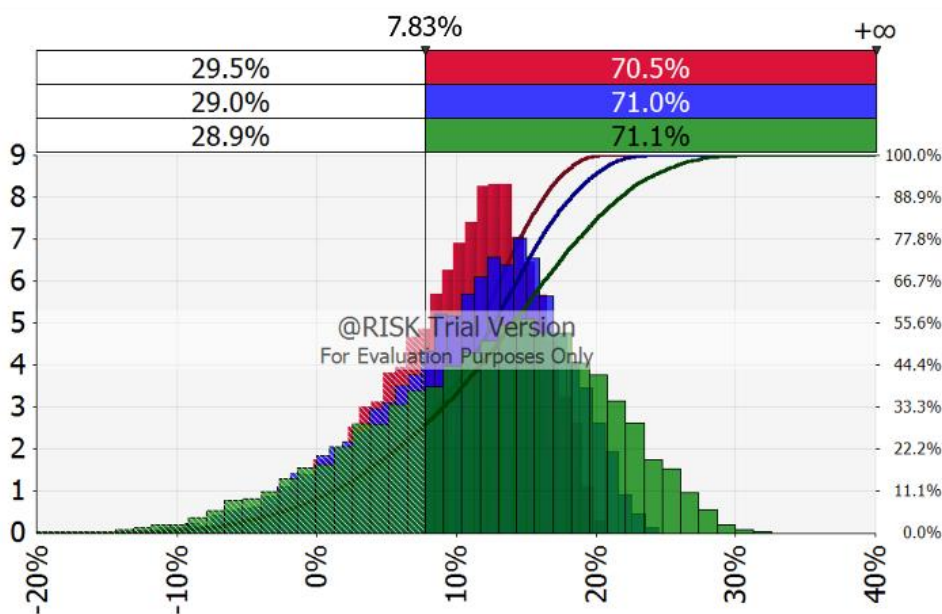


Figure. 4. Cumulative Distribution Functions of IRR

TABLE 9.
 STATISTIC DATA FROM IRR SIMULATION RESULT

Statistic	Value		
	Scenario 1	Scenario 2	Scenario 3
Mean	11.523%	12.443%	14.114%
Median	12.358%	13.300%	14.903%
Standard deviation	5.129%	6.188%	8.002%
Skewness	-0.626	-0.550	-0.355
Kurtosis	2.971	2.860	2.643
Minimum	-6.991%	-8.990%	-10.835%
Maximum	21.532%	25.616%	33.855%

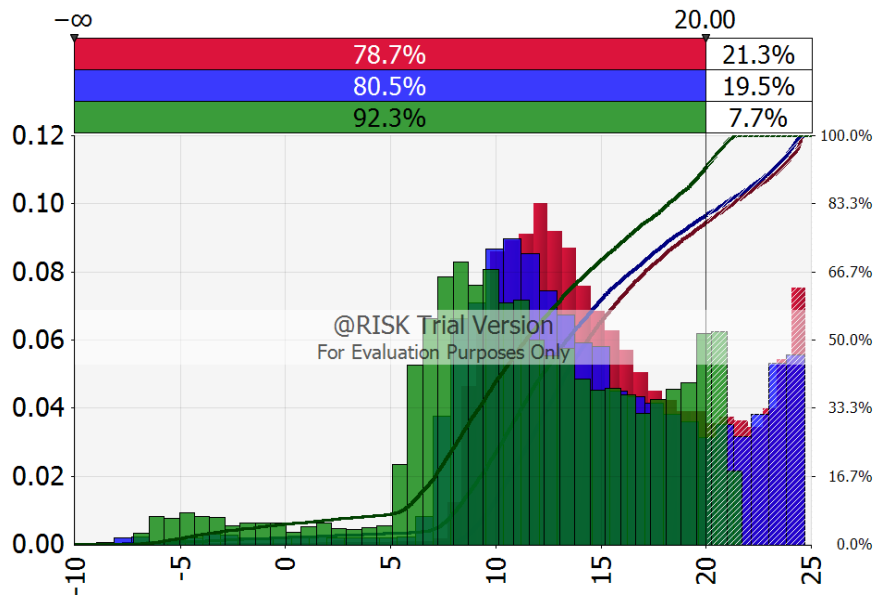


Figure 5. Cumulative Distribution Functions of PP

Table 10.
 Statistic Data from PP Simulation Result

Statistic	Value		
	Scenario 1	Scenario 2	Scenario 3
Mean	15.404	14.244	11.696
Median	14.374	13.371	11.421
Standard deviation	4.740	5.661	5.870
Skewness	0.422	-0.198	-0.588
Kurtosis	2.165	3.556	3.548
Minimum	-2.502	-8.987	-7.221
Maximum	24.747	24.676	21.706

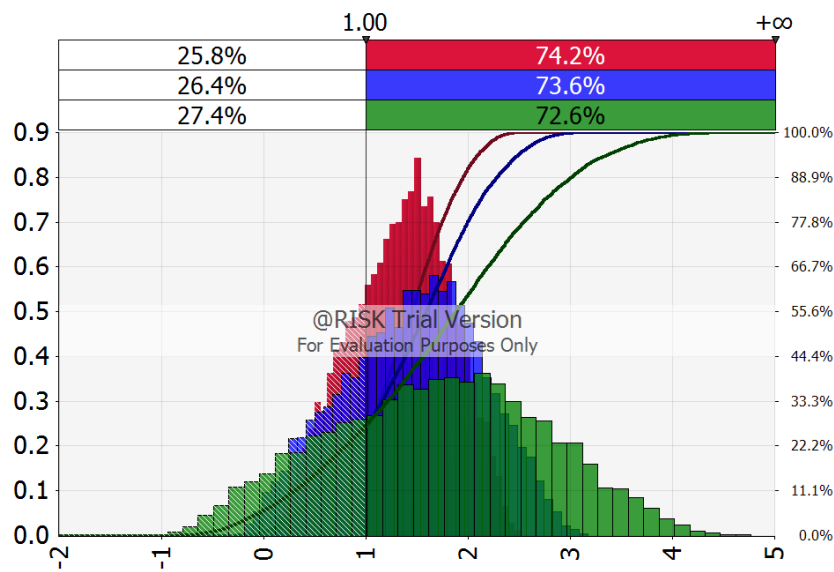


Figure 6. Cumulative Distribution Functions of PI

TABLE 11.
 STATISTIC DATA FROM PI SIMULATION RESULT

Statistic	Value		
	Scenario 1	Scenario 2	Scenario 3
Mean	1.341	1.449	1.686
Median	1.375	1.487	1.724
Standard deviation	0.490	0.669	1.054
Skewness	-0.175	-0.133	-0.037
Kurtosis	2.362	2.363	2.396
Minimum	0.070	-0.276	-1.243
Maximum	2.518	3.171	4.770

E. Sensitivity Analysis

The sensitivity analysis results were obtained by use of relative function of @Risk software. Sensitivity analysis result for each criteria is present in table 14. From that result, interest rate and capital expenditure are most input variable which have negative correlation with NPV, IRR and PI. The annual interest rate will greatly affect the funding of the vessel project. This means that the ship owner needs to make a proper funding decision, the loan

size and loan time, as this will greatly affect the feasibility of the project. As well as the CAPEX, it will greatly affect the project funding. Moreover, coupled with the construction of ships carried out in the domestic shipyard (Indonesia) where the cost of ship build will be more expensive when compared with shipbuilding abroad. In contrast, charter rate have positive correlation. With the decline in the value of the charter rate will be very sensitive to project feasibility parameters.

TABLE 12.
 THE PROBABILITY OF ACEPTANCE CRITERIA
 BASED ON MONTE CARLO SIMULATION RESULT

Acceptance criteria	Probability		
	Scenario 1	Scenario 2	Scenario 3
Prob(NPV>0)	71.3%	72.1%	72.1%
Prob(IRR>7,83%)	70.5%	71.0%	71.1%
Prob(PP<20)	78.7%	80.5%	92.3%
Prob(PI>1)	74.2%	73.6%	72.6%

TABLE 13.
 THE VALUE OF ACEPTANCE CRITERIA

Aceptance criteria	Result		
	Scenario 1	Scenario 2	Scenario 3
NPV (USD)	6,759,518	10,813,703	11,883,958
IRR (%)	11.17%	14.25%	16.11%
PP (year)	14.46	11.82	10.65
PI	1.384	1.779	2.166

Table 14.
Sensitivity Analysis Result

No	Input variables	Correlation Value			
		NPV	IRR	PP	PI
1	R1-probability	0.00	0.00	0.00	0.00
2	R2-probability	-0.02	-0.02	0.00	-0.02
3	R3-probability	0.00	0.00	-0.01	0.00
4	R4-probability	0.01	0.01	0.00	0.01
5	R5-probability	0.00	0.00	0.00	0.00
6	R1-impact	0.00	0.00	-0.01	0.00
7	R2-impact	0.00	0.00	0.01	0.00
8	R3-impact	-0.02	-0.02	0.01	-0.02
9	R4-impact	-0.01	-0.01	0.00	-0.01
10	R5-impact	0.00	0.00	0.00	0.00
11	Capital Expenditure	-0.03	-0.04	0.04	-0.05
12	Crew cost	-0.01	-0.01	0.02	-0.01
13	Lubricating cost	0.02	0.02	-0.01	0.02
14	Repair & maintenance cost	-0.02	-0.02	0.01	-0.02
15	Insurance cost	-0.02	-0.02	0.02	-0.02
16	Administration cost	0.02	0.02	-0.02	0.02
17	Docking cost	-0.02	-0.02	0.02	-0.02
18	Fuel cost	-0.05	-0.05	0.02	-0.05
19	Port charges	0.00	0.00	0.01	0.00
20	Commisioning day	0.02	0.02	-0.01	0.02
21	Charter rate	0.98	0.97	-0.64	0.97
22	Bunker cost saving	0.02	0.03	0.00	0.03
23	Port charges saving	0.00	0.00	0.00	0.00
24	Interest rate	-0.17	-0.20	0.13	-0.19

IV. CONCLUSION

The simulation method especially Monte Carlo could be applied for financial feasibility of 17,500 LTDW Tanker project under risk and uncertainty. From the analysis, it can be concluded:

- 1) Risk of delays in delivery of new vessels risk of insufficient speed design, excessive fuel consumption, insufficient dead weight tonnage (DWT) and risk of tanker having off hire after a year delivery at very low level.
- 2) The 17,500 LTDW tanker investment project is feasible to run under funding decision of 100% of the company's own capital or by bank loan capital till 50%.
- 3) Sensitivity analysis shown the interest rate and CAPEX are the most negative correlation, and charter rate is the most positive correlation with NPV, IRR and PI.

This study still limited in obtaining precise variable input data. Expert opinions and historical data review methods should be applied, not just referring to theoretical calculations. It is suggested that future research with different approaches to refine this research, firstly, determining PDFs of more precise input variables

with near real data. Second, share the factors that influence the financial feasibility of the project by considering external risks, such as potential accidents, piracy and market potential. Third, despite the many limitations of technology and human resources, Indonesia's shipyard is not entirely weak. However, analysis to compare project implementation between domestic and international shipyard will be interesting to do.

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