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RISK BASED TECHNO ECONOMIC ANALYSIS OF COILED TUBING PROJECT OF INDONESIA OFFSHORE FIELD

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ABSTRACT

In oil and gas industry, coiled tubing is well intervention services with the objective to increase the well production. However, utilizing this technology is not free. It is important to analyze the coiled tubing project feasibility to ensure its economic value. This study used Net Present Value (NPV) method that highly influenced by the discount rate used. In addition to Weighted Average Cost of Capital (WACC) method that commonly uses to determine the rate, to accommodate uncertainty and risk associated with the project, Triangular Fuzzy Number (TFN) and Risk Adjusted Discount Rate (RADR) are also used. As the results the estimated discount rates were 13.61%, 13.53% and 16.00% for WACC, TFN, and RADR, respectively. All estimated discount rates gave positive NPVs. This means the coiled tubing project is feasible and profitable.

Keywords: Feasibility study, risk based NPV, discount rate, coiled tubing

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1. Introduction

Oil and gas industry is an industry chacterized with technology-intensive, high-risk, capital-intensive and high level of business uncertainty. The oil and gas industry is a technology-intensive industry because it requires equipments and materials that are technologically advanced and involves professional human resources (Kadir, 2004). The industry becomes a high-risk industry because basically the risks and uncertainties can not be eliminated entirely, but they can be minimized in such a way. Thus decision-making processes need to be carefully examined before a step is taken. Risks in the petroleum industry among others are geological or exploration risk, technical risk, political risk, and commercial risk. Geological or exploratory risk is the probability of accumulation or reserves of hydrocarbons/oils and gases in the bowels of the earth while technical risk is the probability of finding and achieving target that can be produced and developed. Political risk is the probability of gaining or lossing due to government policy changes. Commercial risk is the probability of marketable and sellable of oil and gas reserve that provide benefits for business managers (Sulistiyono, 2011).

Oil and gas industry is a capital-intensive industry since it consumes a large amount of fund or capital. On the other hand, the petroleum industry has unstable prices. For example, during July 2014 to January 2015, the price declined from its originally stable price of US $100/barel to the range of $30/barel (SKK Migas, 2015). Recently, the price has been plunged to the lowest price during the history of the industry. Given the substantial use of financial and capital resources and the uncertainty, it is necessary to have techno economic analysis with taking into consideration risk when determining the feasibility of the project.

In a productive well various problems occur. These reduce the production or even end up with cessation. The problems might be triggered by blockages in the formation zone caused by high skin, high asphaltene content, decreased formation pressure (Engel and Mackey, 2001), falling of unexpected objects into the well, and other causes (Hilts, et al., 1993).

One technology intensively used on oil and gas industry is coiled tubing. The technology utilization began in the mid of 1960s, where it was successfully used for operations such as nitrogen kickoff, well cleanout, acidizing and cementing. Bowen Tools Company is the first company in the world to provide a coiled tubing unit by performing a sand clean out job on an oil well located at the Gulf Coast (Kilgore, 1992).

Basically, coiled tubing technology is performed by incorporating coiled tubing strings into oil and gas well aiming to intervent without changing the structure of the well. This intervention is to maintain or even to increase the well production without disturbing its production processes much. In contrast to the conventional well intervention using Hydraulic Workover Unit (HWU) or Snubbing Unit, coiled tubing has continuous pipe allowing for continuous circulation of pumping during the running time. This practice is saving operational time and the number of personnels involved. In turn, it can reduce the risk of working accident that becomes one of the priorities in the industry. With the growing number of horizontal drilling technologies, coiled tubing can also address horizontal well push/pull operational needs including running, pulling, and shifting downhole flow control devices such as plug and sliding-sleeve circulation tools. This makes coiled tubing the best solution for well intervention at present. In addition to the coiled tubing rigid nature that allows running on well with high or horizontal angle deviation, it also allows to pump different types of fluid to optimize the well production (Kilgore, 1992).

The application of coiled tubing is very diverse both on active wells and brand-new ones. According to Engel and Mackey (2001), there are at least eleven basic applications of coiled tubing including clean out, gas lift, acid stimulation, rotojet, tools, perforating, drilling/milling, chemical, pumping, and cementing. Coiled tubing application can also respond to challenges with objective other than those mentioned previously. For instance, velocity strings, pack off strings and fract acid stimulation (Hassan and Sharkh, 1996). Coiled tubing is considered as the best-judged solution right now to answer to these problems (Kilgore, 1992).

The success ratio of a coiled tubing work is varied. For instance, the application of the velocity string and acid stimulation was succeeded in increasing the production of an oil well from originally 330 BOPD to 1,100 BOPD; the well production increases up to 300% (Hassan and Sharkh, 1996). In addition to technological advantages, popularity of coiled tubing is also drived by economic reason. The cost of using coiled tubing velocity string application is around US $400,000. The cost is 65% lower than using HWU (Hassan and Sharkh, 1996).

The demand for coiled tubing is significantly increased. ICoTA (Intervention & Coiled tubing Association, 2017) showed that the number of coiled tubing units from 1999 to 2017 is growing from 761 units to 1,951. Of that number, the available units in Indonesia are 44; 20 units are for offshore utilization and the rest are for onshore. These equipments are owned by eight oil and gas companies. Business on coiled tubing services is quite competitive. Taking into consideration the nature of petroleum business, a financial feasibility analysis of coiled tubing project services with NPV method was carried out. The method was combined with weighted average cost of capital (WACC), triangular fuzzy number (TFN), and risk adjusted discount rates (RADR) to allow risk and uncertainty when determining the discount rate (Zadeh, 1972, Finger, 2016).

2. Literature Review

Feasibility study can be defined as a study to assess whether or not a business, a project, or an investment is giving profit (Majlender, 2002). There are several aspects to be studied in the feasibility study, namely industry aspect, market aspect, marketing aspect, financial aspect, management aspect, technical and production aspect, human resource aspect, environmental aspect, legal and juridical aspect (Rostianingsih, et al., 2006). However in many occations, feasibility study refers to financial study through assessing technical and economical aspects. The study is well known as techno economy analysis. Many studies on this topic have been done.

Gayem (2015) analyzed building natural gas pipeline from Assaluye, Iran to Austria in central Europe. The pipeline route will pass through Turkey, Bulgaria, Romania, Hungary and Slovakia. Gayem utilized NPV with Excel software. On his study, changes in capital costs, operating costs, gas purchasing price and gas selling price affected project profitability. The result showed that the natural gas pipeline development is economically justified. Araghi, et al. (2013) analyzed the economic feasibility of producing liquefied natural gas (LNG) using the "South-Pars" Iranian gas field based. The result shows that the project is commercially feasible. To investigate the most important factor affecting the project, a sensitivity analysis has been done. As the result, factors affecting the feasibility are LNG price, fixed capital cost and feed gas price. Rinald and Damayanti (2015) used techno economy method such as NPV, internal rate of return, and economic value added to analyze feasibility of a micro hydro power plant project.

Hady, et al. (2009) stressed their study on estimating costs for constructing a chemical plant. Modular based and classical based cost estimation methjods were used. As the result, modular cost estimation gave a better estimation result than the classical one. Other studies on cost estimation were conducted by Sharma (2010) and Finger (2016). Sharma (2010) estimated operating and maintenance costs in the construction of a water treatment plant using regression method. Finger (2016) estimated cost of biomass plant in Europe with problem setting of project short time rotation and risk uncertainty.

3. Methodology

3.1. Net Present Value

NPV is a financial analysis method based on the concept that the value of money is changing with time. The value of money now is not the same with the value of money next month, next year, or some other time even though their nominal currencies are the same. NPV is a popular method to used. It is simpler than Rate of Return method that involves try and error search to find the value. This method is used by most large corporations to evaluate their project or capital investment attractiveness. The Net Present Value is used to determine whether a project is feasible or not feasible. A project with a positive NPV is a feasible project. The project is profitable. Positive NPV means the combined present value of all cash inflows exceed the present value of the cash outflow (Durri, et al., 2016). On the contrary, negative NPV must be avoided. The formula to calculate the NPV is on Equation (1).

$$NPV = \sum_{t=1}^{n} \frac{A_t}{(1+k)^t} \qquad (1)$$

Where:
k = discount rate
A_t = cash inflow – cash outflow
t = time period

When using NPV the overall data should be discounted. The purpose is to deflate future cash flows so their worth is the same as the current time worth. Factor used to discount the value of future cash flows is called discount rate, discount factor, or simply interest rate. Discount rate is usually expressed as a percentage (Glenday and Tham, 2003). As Equation (1) shows, the

NPV value depends on the value of discount rate *k* being used. Estimating *k* accurately is crucial. To determine *k*, this study utilizes three methods, i.e. Weigthed Average Cost of Capital, Fuzzy and Risk adjusted Discount Rate.

3.2. Weighted Average Cost of Capital (WACC)

WACC is a popular quantitative method used to estimate discount rate. WACC is capital structure combination that consists of debt and equity. When a project is financed with debt, the company will be forced to increase equity capitalization to keep the debt ratio reasonable. Therefore, the capital cost should be calculated as the weighted average of the various funds the company uses, such as debt, preferred stock, and common stock equity. WACC reflects project's or company's business risks and target debt capacity to be reached (Bringham, 1985)

The determination of discount rate with WACC, among others, has been done by Bringham (1985), Glenday and Tham (2003), Raheer (1999), Pinteris (2003), and Rau (1997). In general, Equation (2) is used to estimate WACC.

$$WACC = \%SF \; x \; re + \%BL \; x \; rdBL \; x \; (1 - T) \quad (2)$$

where:

$\%SF$: % of self financing
re : cost of equity
T : tax
$\%BL$: % of bank loan (debt)
$rdBL$: cost of debt

Cost of debt represents the cost used to borrow funds from creditors or banks. To estimate the company's cost of debt, information about the current interest rate, default risk (the indebted company fails to meet its obligation) and the marginal tax rate are needed (Bringham, 1985).

Estimating the cost of company's equity is very difficult. In contrast to debt, the cost of equity can not be observed in the market (Bringham, 1985). The type of equity in the capital structure includes ordinary share. In general, common stock estimation is more difficult than bond and preferred stock estimation. This is because in ordinary share, future earning and stock price are not constant. Their values are expected to grow. Whereas in bond and preferred stock, bond interest and preference share dividend are known to be relatively certain (Bringham, 1985). Company's equity cost standard approach is CAPM (capital asset pricing model) that calculated according to Equation (3).

$$re = rf + B \; (rm - rf) \quad (3)$$

where:

rf : risk free of company shares
B : risk index of company shares
rm : risk of company stock

3.3. Fuzzy Method

In the capital/project feasibility analysis, the decision that a project is feasible or not is based on the parameters that are estimated. These parameters are uncertain and risky. So, even though the result states that the project is feasible, the result is still an estimate. There is no guarantee that the actual cash will actually occur. It could be greater/smaller than the estimation. To accommodate the uncertainty in economic analysis, fuzzy is widely used.

Fuzzy related researches used to evaluate the feasibility of public project were conducted by Kahraman (2001) and Lesage (2001). Other researchers who used fuzzy as a decision-making tool are Ward (1989), Carlsson and Fuller (2002), Chiu and Park (1994), Boussabaine and Elhag (1999) and Majlender (2002).

Fuzzy Number Operation

Fuzzy number is a fuzzy subset of a real number that expessing a range of belief. In this study, Triangular Fuzzy Number (TFN) is used (Figure 1). TFN is a simple form of fuzzy but is a good choice to approach a less obvious concept (Dewi and Purnomo, 2004). TFN is the most interesting and appropriate fuzzy number used to represent data or financial information (Sanches et al., 2005).

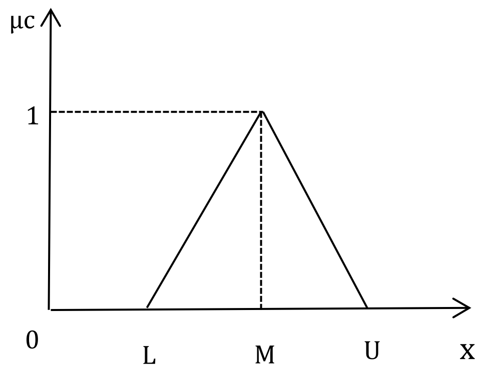

Figure 1. Triangular Fuzzy Number

In TFN every number is presented with three values low L, median M, and upper U such that $\tilde{A} = (L, M, U)$. By definition, a triangular fuzzy number (TFN) has basic characteristic as follows (Zadeh, 1965):

$$\mu\tilde{A}(x) = \begin{cases} \frac{x-L}{M-L}, & L \leq x \leq M, \\ \frac{U-x}{U-M}, & M \leq x \leq U \\ 0, & otherwise \end{cases} \quad (4)$$

Making Decision in Fuzzy Condition

When a decision is made in a state of uncertainty, the decision is expressed within an approximate range. Under such conditions, the decision maker may deal with "slight violation" against the specified limit. This violation in fuzzy programming is referred as tolerance limit or deviation limit that expressed within the lower tolerance range range to the upper tolerable limit. The magnitude of fuzzy decision acceptance, either moving to the lower boundary or upper limit of the target, is represented by a membership function $f_i(x)$ (Zadeh, 1972).

Deffuzification

The input of the defuzzy pros is the fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the fuzzy set domain. Defuzzification is used to obtain crisp values from fuzzy numbers (Chiu and Park, 1994). In this study, defuzzification was performed using the best nonfuzzy performance (BNP) method. The use of the BNP method is simple and practical since it does not require inputing the evaluator preferences. The BNP value of the fuzzy Ři number can be obtained using Equation (5).

$$BNPi = \frac{[(URi - LRi) + (MRi - LRi)]}{3} + LRi \quad (5)$$

3.4. Risk Adjusted Discount Rates (RADR)

RADR method is used in this study because it gives correction to the risk free value to the time function t and the comparison of the expected value is to the certainty value. This method is assessed according to the project characteristics that the project consumps large amount of capital but with short period.

Dealing with the uncertainty of a project risk, owner can utilize two ways to prevent losses in the future. First, compensating with the time value of money that required. For example using risk free interest rate which reflects the safety of past investment opportunities. Second, adding additional compensation if risk is rejected by the decision maker. Decision maker preference for future cash flow uncertainty can be expressed by risk free interest rate i and risk loading v with the following relation (Finger, 2016).

$$RADR = i + v \quad (6)$$

Present value *PV0* calculation formulation in the condition of cash flow uncertainty in period t with the expected value E (Ẍt) are:

$$PV0 = \frac{\text{E}(\ddot{\text{X}}\text{t})}{(1 + \text{i} + v)^t} \quad (7)$$

The risk to the project and the risk that the decision maker choosen are expressed by risk loading v; in every project, the higher the risk and the higher the risk being denied, the higher the value of v. Conversely, if the value of $v = 0$, such as for risk neutral decision-maker, the standard (risk-free) discounting can be applied (Finger, 2016). In some applications, the CAPM model is the basis for determining risk adjusted rate. Thus, the present value of an uncertain cash flow in the period of time can also be defined by the formula below:

$$PV0 = \frac{\text{CEt}}{(1 + \text{i})^t} \quad (8)$$

With CEt is uncertainty of the cash flows' over a period of time t. CEt represents the exact amount of cash flow in a given period t rated by the decision maker as proportional to the uncertainty of cash flow (Ẍt). Since the numerator of Equation (8) represents a cash flow risk (CEt), there is no risk adjustment to the denominator of the equation; the discounting is based on discount rate i only (Hauk, et al., 2014). For simplicity, the ratio of the certain equivalent to the expected cash flow level is written as c as written on Equation (9).

$$\frac{(\text{E}(\ddot{\text{X}}\text{t}) - RP)}{(\text{E}(\ddot{\text{X}}\text{t}))} = \frac{CEt}{\text{E}(\ddot{\text{X}}\text{t})} = c \quad (9)$$

With the value of $c = 1$, $c < 1$, and $c > 1$ for risk neutral, risk rejection and risk acceptance, respectively. In general, the value of c decreases with the increased of cash flow risk and the increased of decision maker's risk rejection. So the risk loading v as a function of risk preference

c is written as Equation (10). The value of c decreases as the value of v increases.

$$v = \frac{(1+i)}{c^{1/t}} - (1+i) \qquad (10)$$

4. Result and Analysis

4.1. Data Collection and Estimation

Coiled tubing application can be implemented at an active well or at a new well. According to Engel and Mackey (2001), a package of coiled tubing project is at least consisted of eleven jobs including clean out, gas lift, acid stimulation, rotojet, tools, perforating, drilling/milling, chemical, pumping and cementing. Coiled tubing utilization is also dealt with jobs such as velocity string, pack off string, and fract acid stimulation (Hassan & Sharkh, 1996). Coiled tubing main equipment includes coiled tubing unit, high pressure pump, nitrogen converter, Wilden pumps, single pump, sand downhole tools. While coiled tubing supporting equipment includes bottom hole assembly, portable lab, nitogen tanks, chemical tank, mixing pumps, water tanks, compressor, sandtrap tank, dimple yoke, manifold, power pack, treating iron, etc. Figure 2 shows some coiled tubing equipments appearence.

In any techo economy studies, data for calculation take a crucial role. Since the feasibility study is for a future project, in many cases data needed are not available; most data are estimated and predicted. Appropriate way to collect and estimate the data should be used so the collected data are the suitable one. According to Yin (2014: 176), basically there are six sources of data collection: document contract, administrative and accounting record, project doer, direct involment and recording, time study, and existing equipment and part.

In this study, two data collection approaches were used. Data are retrieved from experts through direct interview and from project log examination. For the first approach, three key personnel on coiled tubing project, i.e. country financial manager, operation manager dan business development manager, have been interviewed. Second way to collect data is sending Request For Quotation (RFQ) to vendors and third parties who have involved on coiled tubing project. This approach is suitable to collect data on material consumable. Data collected from vendors are including delivery point, estimated volume needed, type and specification of equipments and chemical material supplied, as well as price. Example of RFQ sent to the vendor is shown on Figure 3. Data supplied by vendors confronted by data from finance and asset and maintenance department become the input data of costs and depreciation in NPV calculation.

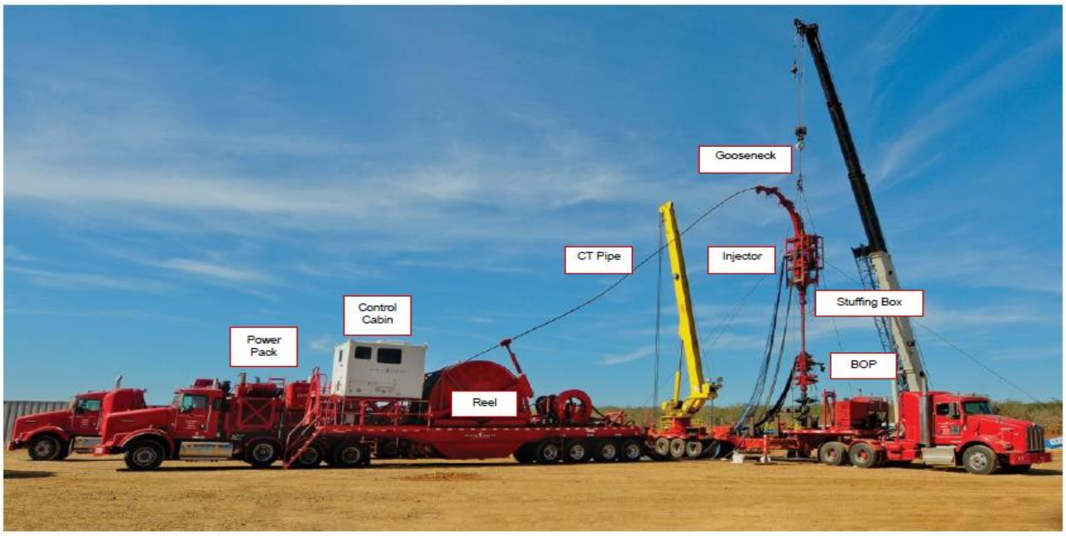

Figure 2. Onshore coiled tubing project

IX. Material/Consumable

Description	Brand Name/Product Code	Packaging Type and Size	Unit rate (USD)
Liquid Nitrogen		Per gal	
Hydrochloric Acid - 32%		Per gal	
Hydrochloric Acid - 15%		Per gal	
Hydrofluoric Acid		Per gal	
Formic Acid		Per gal	
Acetic Acid		Per gal	
Citric Acid		Per lb	
List proprietary Acid Systems (uninhibited):			
(1) Kspar		Bbl	
(2) Sandstone		Bbl	
(3) Silica Scale Acid		Bbl	
Acid Corrosion Inhibitor for HCL and HF to 225 deg F		Per gal	
Acid Corrosion Inhibitor for HCL and HF to 300 deg F		Per gal	
Acid Corrosion Inhibitor for HCL and HF to 350 deg F		Per gal	
Acid Corrosion Inhibitor for formic and acetic acid		Per gal	
High Temprature Booster for Acid Corrosion Inhibitor to 300 deg F, HT-Aid-1		Per gal	
High Temprature Booster for Acid Corrosion Inhibitor to 350 deg F, HT-Aid-2		Per gal	

Figure 3. Example of request for quotation (RFQ) form sent to vendors

Capital cost is cost to buy or rent coiled tubing main and supporting equipments. The cost may consist of equipments' price, shipping and handling costs, insurence costs, value added cost, and installation and testing costs. This cost is estimated using accounting record with capacity and depreciation adjustment.

Direct material cost is consumable material cost that supplied by vendors and third parties. The data is retrieved through RFQ. On the NPV calculation, direct material costs are assumed as consumable costs plus 10% margin. Consumable material includes liquid nitrogen, chemical acid, wellbore cleaning out liquid, and chemical support for cementing.

Manpower required to execute this project is composted of supervisor, operator, specialist engineer, mechanic, electrician, HSE officer, project coordinator, desc engineer dan project manager. Total number of manpowers is 48 personnels. According to Act Number 13 Year of 2003 on Employment and Regulation of Ministry of Labour Number 1 year of 2017 on Salary and Wages, as addition to monthly salary and wages, each employee should receive some supports, bonuses, and compensation such as health insurance, accident insurance, trip allowance, religious eve bonus, and pension fund. All these costs are grouped as direct labor cost on the NPV calculation. Direct labor cost is a component of operational cost. The Act also regulates that labours' salary and wages should be adjusted 10% each year.

Part of operational cost is overhead costs. In this study, overhead costs include cost of personnel trainings, personnel permit and certifications, corporate social responsibility (CSR), rent costs, office rent, office supplies, project costs and utility costs. All costs are estimated based on accounting and administrative records with depreciation rate adjustment. Training, permit and certification held by third parties. The costs are estimated using RFQ.

Even though coil tubing project duration in Indonesia can take up to 10 years but conforming with International Coiled Tubing Assosiaction (IcoTa), in this study depreciation periode for the tubing units is 8 years maximum. This standard also fits with American Petroleum Institute (API) Standard.

Project Financing

To finance the project, the company uses its own resources of 32.15%, i.e., source of capital derived from the company's equity (self financing) and 67.85% derived from commercial bank as a loan. The value of the cost of debt and the margin tax rate are obtained from interviews with corporate experts. In this study the value of the company's cost of debt is 15.18%. While the income tax is 25%. Table 1 summarizes project financial data.

Table 1. Project financial data

Component	Value
Self Financing, *SF*	32.15%
Commercial Bank Loan, *BL*	67.85%
rdBL project	15.18%
Tax	25%
B	0.48
rm	26.43%
rf	10.80%

The cost of company equity is obtained by applying capital asset pricing model (CAPM) through Equation (3). The formula has a factor of (*rm* - *rf*) which is the average risk premium of stock obtained from reducing the major risk of company stock *rm* with the value of risk free of company shares *rf*. In addition, there is company stock index factor *B*. Using Equation (3) the company equity cost *re* is 18.30%.

4.2. Discount rate calculation with WACC

WACC method is used in this study because the method reflects business risk and target debt capacity of the coiled tubing project. Data needed for this calculation are summarized on Table 1.

There are two main parameters of WACC: first, cost of debt or company debt cost *rdBL*. *rdBL* is linear to the percentage of commercial bank loans % *BL* and the amount of tax. The second is the cost of equity or the firm's equity cost *re*. This cost has factors of the company's major risk *rm*, the company's stock risk-free *rf* and the company's risk index. The equity cost is linear to the percentage of the capital coming from the firm equity or self-financing % *SF*. It can be stated that the WACC discount rate covers all parameters of the project's capital that derived from company equity and from commercial bank loan. WACC is particularly suitable when analyzing coiled tubing services' projects where the capital source of project comes from the two main sources. By using Equation (2), the WACC discount rate was calculated as 13.61%.

4.3. Discount rate with Fuzzy Method

Fuzzy method was used in this study because it is more represented the actual condition of WACC values. This approach is also more suitable to be used when dealing with uncertain conditions and risks. WACC factors that are fuzzy incuding company's stock risk free *rf*, company's stock index *B*, company's stock major risk *rm*, the cost debt *rdBL* and the income tax. Parameters of project fuzziness are given by the decision makers as listed on Table 2.

Table 2. Project factors and fuzzy value

Factor	Value	Deviation Interval
rf	10.80%	±10.40%
B	0.48	± 9.30%
rm	26.43%	± 8.90%
rdBL	15.18%	(-9.60%, 5.40%)
Tax	25%	± 3%

By using triangular fuzzy number (TFN) model, each parameter value that forming WACC value is summarized on Table 3.

Table 3. Fuzzy value of cost of equity, cost of debt and WACC

Factor	L (lower limit)	M (median limit)	U (upper limit)	X (crisp value)	μ X L	μ X U
re	0.14968	0.18302	0.21947	0.18406	-	0.971619
rdBL	0.10395	0.11385	0.11880	0.11220	0.833257	-
WACC	0.11865	0.13609	0.15110	0.13530	0.954832	-

Table 3 clearly shows that the cost of debt *rdBL* comes up with a large fuzzy value (close to 1) in its lower bound (low value). This indicates that the decision maker has a high confidence level that during the economic life of the project, it will be a possibility of a decline rather than an increase in the interest rate of the commercial bank. For the cost of equity *re*, the large value (which is 0.971619) is in the upper bound area due to the deviation of the upper and the lower limits of *B* value is the same. This indicates that the rate of return on the composite stock price index and the company's stock index price is very volatile. In this setting, decision makers tend to expect an increase in the rate of return of the composite stock price index and the company's stock index price that causing the equity cost is higher than its deterministic value obtained from Equation (3). However, although the equity cost is higher, it does not make the fuzzy WACC larger since the proportion of equity cost is much smaller (32.15%) than the proportion of total debt cost (67.85%). Even though the debt cost decreases. In the end, the fuzzy WACC value is lower than the deterministic WACC value by 0.955. The fuzzy discount rate value is 13.53%.

4.4. Discount Rate with RADR

The value of risk loading *v* shows a high *v* value along with a low value of *c* (a comparison of *CEt* values versus *E* (*Xt*)) in a low *t* period. This means that the value of risk loading *v* is higher if the decision maker tends to reject the risk, $c < 1$ in the short *t* period. Conversely the value of *v* is lowered by the high value of *c* in the long *t* period. Its significance is the value of risk loading *v* is lower if risk takers tend to accept risk, $c > 1$ in long period.

To get RADR value for t = 5 and i = 10.80%, the values of v used on this study are within 0 to 12 %, using Equation (10), v = 0.00% for value c = 1; v = 2.35% for the value of c = 0.9; v = 5.04% for the value of c = 0.8; v = 8.16% for c = 0.7 and v = 11.87% for c = 0.6. RADR discount rate value for each corresponding v is calculated with Equation (6). If c is 1, the RADR discount rate equals to the value of risk free setting. If the value of c is 0.6, the RADR discount rate is higher than the IRR value. These two values can be ignored; the remaining the RADR rates becomes triangular fuzzy number with the value of Lradr, Mradr, and Uradr as 0.1316, 0.1586, and 0.1899, respectively. After defuzzification with Equation (5), the RADR discount rate was calculated as 16.00%.

4.5. NPV and Sensitivity Analisys

To calculate NPV using Equation (1), project's cash-in is the project price submitted on bidding document. Applying the WACC discount factor k = 13.61% and using collected data cost, the NPV is 964,215,294 IDR. In a project feasibility analysis, a positive value of NPV or NPV > 0 means the project is feasible to run.

Using the same equation and data but with the fuzzy method discount rate, i.e. 13.53%, the NPV value is 979,733,960 IDR. This value is slightly greater than the value obtained by WACC method by 15,518,666 IDR. The result indicates that taking risks into consideration will even give greater confidence to run the project.

Calculating the NPV with RADR discount rate of 16.0%, yields the NPV as 520,191,242 IDR. This value is smaller than the value obtained by WACC and fuzzy methods, but it is still positive. It means the project remains feasible. The NPV with RADR discount rate is the smallest compared to the NPV of WACC and fuzzy discount rate. The NPV provides more value to project risk by considering short project period, high capital value coupled with uncertain condition. Next is NPV's sensitivity analisys.

As the feasibility analysis come up with the project is good to go, sensitivity analisys were performed to see the impact of raising the capital and operational costs to the NPV. The result shows that the increment of 1.121% of the capital cost will make the NPV become zero. Conversely the NPV will still be positive as long as the capital cost increment is less than 1.121%. For the operational cost, the NPV will be zero when the cost increases by 0.434%. Comparing these two costs, clearly seen that the operational cost is more sensitive to the NPV than the capital cost; the increment of the operational cost degrades more on the NPV than the same increment of the capital cost on the NPV.

As clearly shown on Table 4, sensitivity analisys with fuzzy and RADR discount rates give similar pattern as sensitivity analisys with WACC discount rate; i.e. NPV is more sensitive toward the changing of operational cost than toward the changing of capital cost but with different rate. All discount rates on this study tell that operational cost should be managed more carefully to maintain the project profitability.

Table 4. Summary of sensitivity analysis

NPV based	Increment Cut off (%)	
	Capital Cost	Operational Cost
WACC	1.121	0.434
Fuzzy	1.136	0.44
RADR	0.64	0.248

5. Conclusion

Based on the data gathered and estimated, and assumption used, weigthed average cost of capital, fuzzy, and risk adjusted discount rates and their corresponding net present values are 13.61%, 13.53%, and 16.00%, and 964,215,294 IDR, 979,733,960 IDR, and 520,191,242 IDR, respectively. Considering the net present positive values, coiled tubing offshore project in Indonesia is feasible and profitable.

Indonesia's coiled tubing offshore project net present value is more sensitive toward the changing of the operational cost than the changing of the capital cost. Using risk adjusted discount rate result, the net present value will become negative if the operational cost increases for more than 0.248% or it will be negative if the capital cost increases for more than 0.64%. Coiled tubing project services should manage its operational cost more carefully.

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REFFERENCES

Araghi, M., Heidari, A., and Kasrei, Z. 2013. Feasibility study of liquefied natural gas project for the "south-pars" gas field of Iran. Econ. Rev 17(2), pp. 252-263.

Boussabaine, A. and Elhag, T. 1999. Applying fuzzy techniques to cash flow analysis.

Constr. Manag. Econom 1(1), pp. 745-755.

Bringham, E.F. 1985. Financial Leverage and Use of the Net Present Value Investment Criterion: A Reexamination. The Dryen Press, Brooklyn, NY.

Bringham, E.F. 1985. Financial Management: Theory and Practice. The Dryden Press, Brooklyn, NY.

Carlsson, C. and Fuller, R. 2002. Real option evaluation in fuzzy environment. Proceeding of the International Symposium of Hungarian Researchers on Computational Intelligence 2(1), pp. 69-77.

Chiu, C. and Park, C. 1994. Fuzzy cash flow analysis using present worth criterion. The Engineering Economist 2(3), pp. 113-139.

Dewi, S.K. and Purnomo, H. 2004. Aplikasi Logika Fuzzy untuk Pendukung Keputusan. Graha Ilmu, Jakarta.

Durri, A., Saifi, M., and Azizah, D. 2016. Analisis kelayakan usaha dalam rangka rencana pengembangan usaha (studi kasus pada PO. Zena Pariwisata Malang). Jurnal Administrasi Bisnis (JAB) 1(2), pp. 91-99.

Engel, S. and Mackey, P. 2001. Opportunities to improve the success rate of coiled-tubing operations. Society of Petroleum Engineer 1(2364), pp. 1-14.

Finger, R. 2016. Assessment of uncertain returns from investment in short rotation coppice using risk adjusted discount rates. Biomass & Bioenergy 1(3), pp. 320-326.

Gayem, A. 2015. A comparative study of the economic feasibility of building a gas pipeline from Iran to Europe via Turkey to Austria destination. SAUSSUREA 3(2), pp. 18-30.

Glenday and Tham. 2003. What Weight in the WACC? Terry Sanford Institute of Public Policy.

Hady, L., Dylag, M., and Wozny, G. 2009. Investment cost estimation and calculation of chemical plants with classical and modular approaches. Chemical And Process Engineering 3(5), pp. 319-340.

Hassan, M. and Sharkh, A. 1996. Applications of coiled tubing in zadco wells. Society of Petroleum Engineer 2(1457), pp. 1-16.

Hauk, S., Knoke, T., and Wittkopf, S. 2014. Economic evaluation of short rotation coppice system for energy from biomass. Elsevier 3(6), pp. 435 - 448.

Hilts, R., Fowler, S., and Pleasants, C. 1993. Fishing with coiled tubing. Society of Petroleum Engineer 1(4353), pp. 1-14.

ICoTa. 2016. Annual Report 2016. ICoTa.

Kadir, A.W. 2004. Resiko Bisnis Sektor Hulu Perminyakan. PT. Pradnya Paramita, Jakarta.

Kahraman, C. 2001. Fuzzy versus probabilistic benefit/cost ratio analysis for public work projects. Journal International 2(2), pp. 705-718.

Kilgore, M. 1992. New muscle for coiled tubing. The 24th Annual Offshore Technology 2(4), pp. 112-121.

Lesage, C. 2001. Discounted cash flow analysis: An interactive fuzzy arithmetic approach. Eropean Journal of Economic and Social System 3(2), pp. 49-68.

Majlender, P. 2002. Strategic investment planning by using dynamic decision Trees. Proceeding of the 36th Hawaii International Conference of System Sciences (HICSS'03). Hawaii.

Pinteris. 2003. Notes on Weighted Average Cost of Capital (WACC). Illionis: Departement of Finance, College of Business University of Illionis at Urbana – Champaign.

Rau, R. 1997. The Weighted Average Cost of Capital : An introduction. Kraneert School, Purdue University.

Rinald, A.M. and Damayanti, S. 2015. Financial feasibility analysis of gumantimicro hydro power plant project. Journal of Business and Management 4(3), pp. 352-362.

Rostianingsih, S., Raharjo, A., and Setiawan, B. 2006. Pembuatan aplikasi manajemen proyek dalam mengelola proyek di PT. X. Proceeding Seminar Ilmiah Nasional Komputer dan Sistem Intelijen (KOMMIT 2006) 2(1), pp. 56-60.

Sanches, L.A., Montevechi, P.E.D., and Arnaldo, J. 2005. Capital Budgeting Using Triangular Fuzzy Number. V Encuentro Internacional de Finanzas, Santiago, Chile.

SKK Migas. 2015. Laporan Tahunan SKK Migas Tahun 2015. Jakata.

Sulistiyono. 2011. Analisa kelayakan penambahan sumur produksi minyak dan gas bumi (studi kasus PT. Conoco Phillips Indonesia). Jurnal Ilmiah MTG 4(1), pp. 43-55.

Ward, T. 1989. Fuzzy discounted cash flow analysis. Industrial Engineering Journal 2(4), pp. 91-102.

Zadeh, L.A. (1965). Fuzzy Sets. Polytecnic press, Brooklyn, NY.

Zadeh, L.A. (1972). Fuzzy Sets & Systems. Poltechnic press, Brooklyn, NY.