Evaluation of oil investment projects under uncertainty using simulation methods

To grade of Master on Corporative Finance

Master’s Thesis by the 2nd year student
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Abstract

This thesis is based in evaluation oil camp investment with different approach evaluations of the investment.

The traditional methods like Discount cash flow (DCF) is the usual method with the firms and investors based his decision if some project or investment is a profitability or not. This kind of approach cannot evaluate all the possible variables of the project without understand the framework and scope about the real dimension of the investment.

In this context the Real Options approach can evaluate the investment with managerial flexibilities and this model incorporate the uncertainty factors inherent of the RO approach, and the flexibility is possible to overcome the limitations and complement the traditional methods investment evaluation.

This document proposed to quantify not only the uncertainties of the price of oil and investment, but also the uncertainty in the price of the dollar, the proposed model has considered a series of uncertainty factors through the application of real options analysis, which considers the flexibility and impacts of the uncertainty factors about the value of the oil investment abroad than the NPV method.

Keywords: Project Value, Real Options, GMB, Oil price, Dollar, stochastic process

Contents

Introduction

A fundamental issue in the field of strategic financial management is the choices and setting the correct course for the company.

There is a large amount of research in this field where the context for corporate strategic decisions and their impact on performance are studied. These strategic decisions imply investments which imply commitments of resources for future initiatives under uncertainty. Therefore, the role of uncertainty is essential when making these decisions.

The prices of raw materials rose during the first quarter of 2022, due to various Geopolitical and pandemic factors worldwide and with a continuous growth in demand having several restrictions in supply.

These events have caused a general increase in commodity prices when there was an economic recovery in mid-2020 with an increase in demand driven by easing concerns about the COVID-19 pandemic. This new time and trading of raw materials has been growing as the global economy recovers, while the commodity production sector is still well below its pre-pandemic level burdened by several years of weak investment in new capacity. production, and supply problems.

It is important to mention that this environment creates a high level of uncertainty compared to previous years, since oil is one of the most volatile raw materials in the world market.

Crude Oil Price Movements

Crude oil spot prices rebounded in January, compared to the previous month, as oil futures markets surged. Crude prices were supported by *strong global oil market fundamentals amid dissipating fears about the impact of the COVID-19 Omicron variant and geopolitical risks, which raised concerns about near-term oil supply. The OPEC Reference Basket increased $11.03, or 14.8%, to settle at $85.41/b in January, its highest monthly value since September 2014. Similarly, crude oil futures prices increased on both sides of the Atlantic with the ICE Brent front month up $10.77, or 14.4%, in January to average $85.57/b and NYMEX WTI rising by $11.29, or 15.7%, to average $82.98/b. As a result, the Brent/WTI futures spread narrowed by 52¢ to an average of $2.59/b. The market structure of all three crude benchmarks – ICE Brent, NYMEX WTI and DME Oman – strengthened significantly in January over the previous month as market perception of the outlook for the supply-demand balance improved. Hedge funds and other money managers turned more positive about oil prices, increasing net long positions to their highest level since last November*.

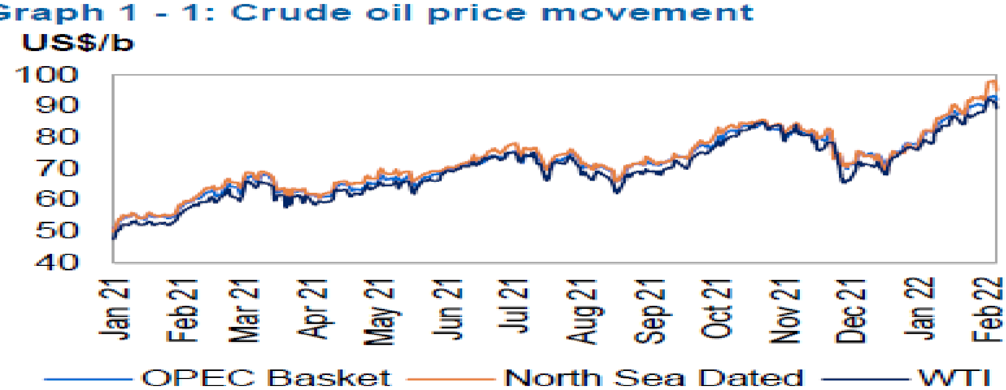
Source: OPEC Monthly Oil Market Report – February 2022

Balance of Supply and Demand

Demand for OPEC crude in 2021 is revised up by 0.1 mb/d from the last month's assessment to stand at 27.9 mb/d, around 5.0 mb/d higher than in 2020. Demand for OPEC crude in 2022 was also revised up by 0.1 mb/d from the last month's report at 28.9 mb/d, around 1.0 mb/d higher than in 2021.

Source: OPEC Monthly Oil Market Report – February 2022

Graph 1 - 1: Crude oil price movement



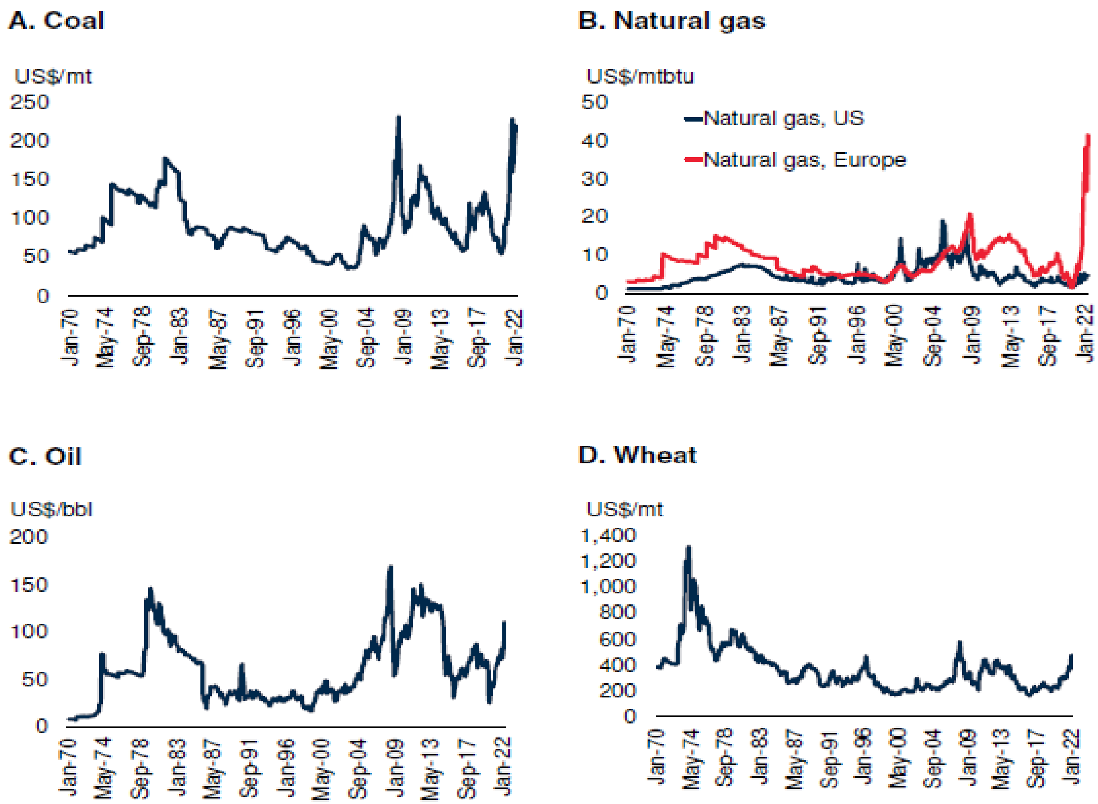
Sources: Argus, OPEC and Platts.

Source: OPEC Monthly Oil Market Report – February 2022

In these charts' projections of the World Bank, we can notice the world bank forecasts in October 2021 and the changes made with the new forecasts made in April of the current year, which have an upward trend in contrast to the previous estimates.

World Bank Commodities Price Forecast (nominal U.S. dollars) — Released: April 26, 2022

							Percent change from previous year		Differences in levels from October 2021 projections	
Commodity	Unit	2020	2021	2022f	2023f	2024f	2022f	2023f	2022f	2023f
Price indices in nominal U.S. dollars (2010=100)										
Energy a/		52.7	95.4	143.6	125.8	110.8	50.5	-12.4	91.7	30.6
Non-Energy Commodities		84.4	112.0	133.5	121.7	117.8	19.2	-8.8	49.4	11.5
Agriculture		87.5	108.7	127.9	118.0	117.8	17.7	-7.7	40.8	11.7
Beverages		80.4	93.5	103.5	99.7	100.2	10.7	-3.7	23.1	8.7
Food		93.1	121.8	149.7	134.2	133.5	22.9	-10.4	57.2	15.7
Oils and Meals		89.8	127.1	164.9	141.9	140.6	29.7	-13.9	75.1	16.2
Grains		95.3	123.8	149.0	133.6	132.6	20.4	-10.3	55.9	19.0
Other food		95.5	113.1	130.3	124.8	125.1	15.2	-4.2	34.8	12.2
Raw Materials		77.6	84.5	87.2	87.8	88.4	3.2	0.7	9.6	3.6
Timber		86.4	90.4	86.4	89.5	90.8	-4.4	3.6	0.0	-1.7
Other Raw Materials		67.9	78.0	88.1	85.9	85.9	12.9	-2.5	20.2	9.2
Fertilizers		73.2	132.2	223.7	198.3	168.5	69.2	-11.4	150.5	82.2
Metals and Minerals b/		79.1	116.4	134.8	120.6	112.1	15.8	-10.5	55.7	3.1
Base Metals c/		80.2	117.7	143.9	131.9	123.8	22.3	-8.3	63.7	13.3
Precious Metals		133.5	140.2	144.4	131.5	127.0	3.0	-8.9	10.9	-8.7
Price data in nominal U.S. dollars										
Energy										
Coal, Australia	$/mt	60.8	138.1	250.0	170.0	154.7	81.0	-32.0	130.0	80.0
Crude oil, Brent	$/bbl	42.3	70.4	100.0	92.0	80.0	42.0	-8.0	26.0	27.0
Natural gas, Europe	$/mmbtu	3.2	16.1	34.0	25.0	22.3	111.2	-26.5	21.4	15.8
Natural gas, U.S.	$/mmbtu	2.0	3.9	5.2	4.8	4.7	33.3	-7.7	1.2	0.9
Liquefied natural gas, Japan	$/mmbtu	8.3	10.8	19.0	14.0	13.3	75.9	-26.3	7.6	4.0



Sources: Haver Analytics; World Bank.
A.-D. Monthly data from 1970 to March 2022. Prices deflated by January 2022 Consumer Price Index (CPI). Oil refers to the Dubai benchmark. Wheat refers to the US HRW benchmark.

Given that decision-making is fundamental in any field and to decide, and for the evaluation of projects, financial models are needed that provide useful and effective information, considering as much information as possible.

This being a time of great uncertainty at the global level, especially for raw materials such as oil and gas, with the oil price variable being highly uncertain in the macroeconomic context, which must be analyzed and will be decisive in the evaluation. The financial aspect of investing in an oil field project is closely related to the price, which determines whether an investment of large volumes of money and time like this could be profitable.

For the financial evaluation of our project, we must correctly measure the current conditions of high volatility and uncertainty because of the global economic political situation that we are facing.

When significant variations occur in any of the relevant independent variables during the execution of a project, the original model is completely distorted, without the capacity or flexibility that management must act. These variations can be of various aspects, whether in the business environment, in the market or in production, which can have a significant impact on the project. These impacts must be able to be quantified and thus be able to be corrected in the development of the project. Therefore, it is very important to have courses of action during the project that can avoid a negative result, so it becomes essential to work on investment models that may involve uncertainty. The real options allow to quantify the work with different alternatives between the beginning, during and the end of the project, knowing the time, the uncertainties and the flexibility that maximize the value of a project.

The traditional and widely used methods of financial evaluation of projects are the discounted cash flow approach (DCF) or NPV, which is a simple and easy method to apply and where the risk is assumed in the cost of capital but the intrinsic flexibility of the projects is not taken into account, and in the event of changes in any of the relevant independent variables of the project, they can throw Very different results from those estimated in the previous analysis, which considered a single scenario projected with data that is immutable and without margin for strategic management. That is why companies and investors today are much more dynamic and seek to quickly adapt to market changes.

L*ed to applying the approach may lead to undervalued investment opportunities, sub-optimal decisions, and underinvestment (Trigeorgis 1993).*

In this type of large projects, flexibility must be incorporated, traditional NPV or IRR techniques being static, such methods can lead us to make incorrect decisions. For this reason, we will focus on the real options methodology which determines the optimal moment of investment, by incorporating flexibility in the financial analysis, it also allows us to adapt to unexpected changes in the different processes of the project or the investment, such as changes in prices, new market environments, new competitors, innovations in operations or technology.

Now, there is a relationship between both elements: the greater the uncertainty, the greater the flexibility, since decision-making can vary at any time, and this is reflected in the price of the option, which will be higher (Mauboussin, 1999)

In this thesis we analyze the same project and compare them, first through traditional methods and later different evaluation criteria methods will be established, where the most outstanding will be the Black-Scholes model, Montecarlo Simulation with cash flows and the Brownian geometric method. and finally, the binomial tree method and to be able to establish the different options that the Real Options approach gives us.

"*Is a systematic approach and an integrated solution, using financial theory, economic analysis, management and econometrics to value real assets, in a dynamic and uncertain environment where business decisions are flexible in the context of strategic capital investment" Mun (2006), (p. 17).*

If we extrapolate this to the field of investment decisions, we can postulate the following question:

How to better manage strategic decisions in uncertain conditions for companies and investors?

The research goals

Determinate the real added value in a scenario of high uncertainty the Real Options approach in the strategic financial valuation of a large-scale project.

Hypothesis

Identify and measure whether the flexibility granted in the Real Options approach can really be valued in the evaluation of large-scale projects identifying the flexibilities of the project.

Research Objectives

Apply all the alternatives action granted by the Real Options approach in this type of project

Estimate which of the variables that with a random behavior have more influence the evaluation of the project

Demonstrate the impact of the inclusion of real options on the value of a project.

Maximize the use of available information as well as advances and studies in the application of real options by applying it in the valuation of an oil extraction field.

Incorporating the uncertainty, it is understood that a project has flexibilities and by having these flexibilities we can use the Real Options methodology; The real options propose several alternative actions and thus make the decision between one and the other, which depend on the project managers.

Literature review

As part of the development of this work we are going to study the investment models that we will use.

Net Present Value (NPV)

The Net Present Value approach is widely used in Finance for the valuation of projects, since it recognizes the time value of money and represents the risk through an adjustable interest rate, r. So, you have a powerful and simple tool for making financial investment decisions.

The NPV is a technique that calculates the present value of a certain number of future cash flows originated by an investment. The methodology consists of discounting each one of the projected future flows generated throughout the useful life of oil extraction at the present value, through a determined discount rate. Once the results of the future flows are obtained, the initial investment incurred in the project is subtracted and thus the present value is obtained. t= 1.2, ...tn. These flows are discounted at the rate of (1 + r) ^t, where r is the discount rate.

Formally NPV formula:

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} - I_0$$

Where:

CF_t : Net Cash Flows at time t

r : *Discount rate*

I_0 : *Initial investment cost*

T : *Time of final cash flow*

since it considers the explicitly value time of money, where the net present value is calculated by subtracting the initial investment from a *project the present value of its cash inflows, discounted at an equivalent rate to the cost of capital of a company. From this, it follows that the net present value depends on future cash flows (Brealey, Myers, & Allen, 2013).*

We must calculate the present expected value of benefits to be generated by the project. Then we calculate the present value of costs and expenses of the project in the future. Finally, we subtract the benefits minus the cost and expenses and obtain the current value of the project.

Results

If VPN < 0, reject the project

If VPN ≥ 0, the project is approval

The biggest agents that generate errors in valuations are usually: changes in market conditions, valuation generated by incomplete data, subjective data, managerial decisions that correspond to different interests and, not least, macroeconomic volatility (Damodaran, 2006).

Weighted Average Cost of Capital (WACC).

A company obtains the funds to invest in productive assets from various sources. The main sources are the shareholders and the owners of the financial debt and the company itself through its reserves, all these funds are used for the company's investments. Therefore, the average cost of these funds is the firm's average cost of capital.

$$WACC = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)(1-t)$$

Where:

E = market value of equity

D = market value of debt

r_e = cost of equity

r_d = cost of debt

t = corporate tax rate

It is important to point out that the WACC is related to the opportunity cost, since it is assumed that the investor is able to identify all his investment possibilities and evaluate them according to the risk and the profit to assume for these possible investments.

It is necessary to differentiate when the investments are made with capital or debt. They highlight the importance of evaluating projects according to their own risk and not that of the company that materializes them. (Brealey, Myers, & Marcus, 2013)

Internal Rate of Return (IRR)

It is the intrinsic rate of return of the project. This measure helps us with the evaluation if the IRR of the project is higher than the cost of capital then the project is accepted, but the IRR rate is less than the cost of capital indicates that the profitability of the project is less than the profitability required for the project.

$$0 = \text{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0$$

where:

C_t = Net cash inflow during the period t

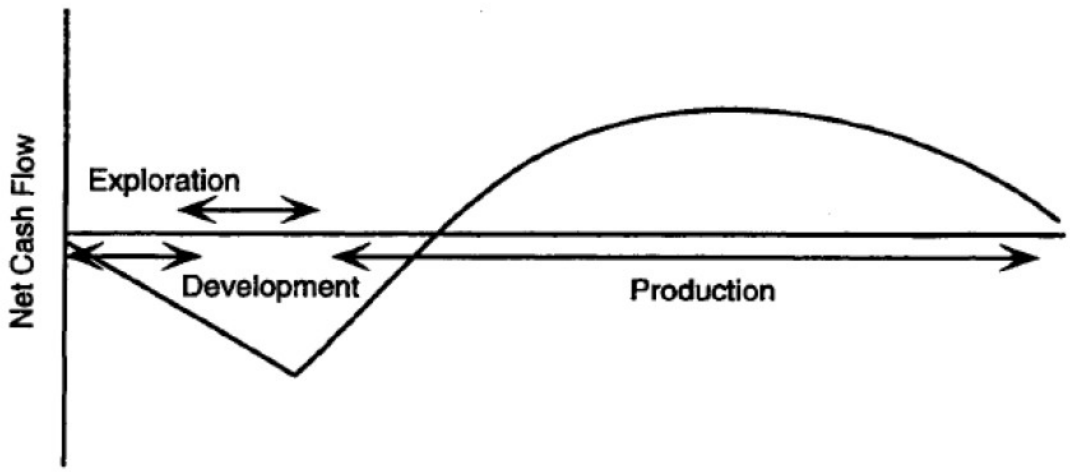
C_0 = Total initial investment costs

IRR = The internal rate of return

t = The number of time periods

If the IRR is equal to the cost of capital, it means that the profitability of the project allows the rate demanded by investors to be met and there would be no increase or decrease in equity. [Weston and Brigham, 1994]

This graph represents the phases of exploration and drilling or development, which is investment; and the second part is the productive phase where positive cash flows are already generated with the extraction, transportation, and sale of oil.



Source: Lerche, I., & Mackay, J. (1999). Economic risk in Hydrocarbon Exploration. Elsevier Science & Technology Books.

$$S_t = S_0 e^{\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t}$$

St, is the future value of the asset

$S0$, initial price of the asset

μ, trend constant σ, volatility constant

Wt, Standard Brownian Motion

It's important mention these features:

$W_t \sim N(0,t)$

$W_{t+\Delta t} \sim N[0,(t+\Delta t)]$

$(W_{t+\Delta t} - W_t) \sim N(0, \Delta t)$

The geometric Brownian motion describes the performance of the asset price, equation:

$$Ln(S_t) = Ln(S_0) + \left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t$$

For the modeling of the oil price and the exchange rate in the financial model to be developed in this document, the Geometric Brownian model with jump will be used.

An important feature of the geometric Brownian motion process is that it is lognormally distributed, meaning only positive values for the randomly varying quantity, which for the needs of finding oil prices negative values or in this case prices are not desirable for price modeling purposes.

The Geometric Brownian motion (GBM) is the right choice because of its computational ease, it is suitable for the effects of uncertainty and irreversibility. In addition, the fact that it can generate a reversion to the mean is considered very appropriate.

$$S_t = S_0 + \left(\mu - \frac{1}{2}\sigma^2\right) * \delta t + \sigma\sqrt{\delta t}\, W_t + \ln(1+v)N_t$$

Real Options

Relationship with Financial Options

Position	*Payoffs at t if S*>K*	*Payoffs at t if S*<K*
Sell call	-(S*-K)	0
Buy put	0	K-S*
Buy stock	S*	S*
Total	*K*	*K*

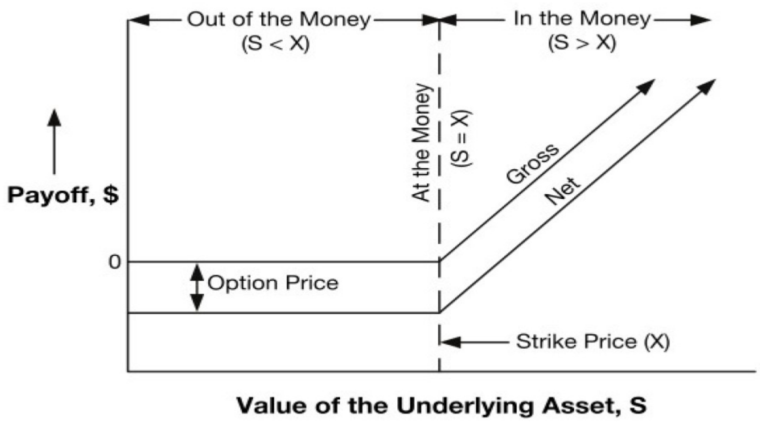
Financial options were presented in a 1973 publication called "The Price of Options and Corporate Liabilities" in the "Journal of Political Economy" at the University of Chicago, where Fisher Black and Myron Scholes showed the development of an analytical solution at the price of an option on a stock at a given time.

In order to understand Real Options, they are based on the theoretical concept of Financial Options, which are a financial derivative, in which a contract between two parties is stipulated where one of the parties has the right to buy (call option) or sell (put option) but not the obligation of an amount previously agreed by the parties of the underlying asset at a price also previously determined and on or before the agreed expiration date (European or American option).

Call option

The call option of a financial asset is a contract that gives the buyer the right, but not the obligation, to buy an asset at a given time T at an exercise price X.

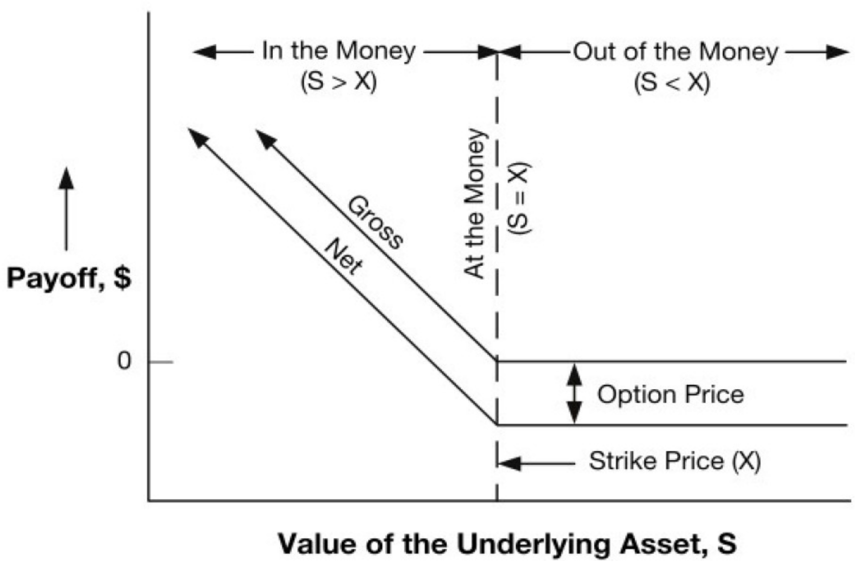
At time T the price of the stock is $S > X$, the buyer will exercise the option, and will obtain a profit equal to $S – X$ by selling it immediately at the market price. But if at the time of expiration, it is true that $S < X$, the option is not exercised. Its value, in that case, would be null and it would obtain a benefit equal to 0



Source: "Equacions en derivades parcials"

Put option

It is a contract that gives the holder the right to sell a share at a given instant T at a fixed or exercise price X independent of the market price of the asset. At expiration T the price of the asset is S < X, the buyer exercises the option, otherwise if S > X, the option is not exercised, and its value is 0



Source: "Equacions en derivades parcials"

The biggest agents that generate errors in valuations are usually: changes in market conditions, valuation generated by incomplete data, *subjective data, managerial decisions that correspond to different interests and, not least, macroeconomic volatility (Damodaran, 2006).*

The methods that determine the theoretical value of the option are:

Monte Carlo simulation

This Monte Carlo simulation method is a numerical simulation method that is often used in Finance for option pricing, it is a widely used method to simulate financial assets with stochastic processes.

$$S_t = S_0 e^{\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t}$$

Published by Fisher Black and Myron Scholes, with the collaboration of Robert Merton in 1973, it was called Black-Scholes and was initially used to estimate the present value of a European call option. or sale (put), of shares at a future date, then its use was expanded in more options. This approach assumes the stock prices are random and that volatility can be modeled as constant over time and calculates the price of European call and put options

The calculation of the option parameters is expressed:

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(Rf - \frac{\sigma^2}{2}\right)(T - t)}{\sigma\sqrt{T - t}} \qquad d_2 = d_1 - \sigma\sqrt{T - t}$$

Call and Put option

$$call = SN(d_1) - Xe^{-rT} N(d_2), put = Xe^{-rT} N(-d_2) - SN(-d_1)$$

The function N(x) is the cumulative probability function for a normal standardized variable. The variable that implicitly has risk is the price and we will use all the variables to estimate the price of a barrel of oil. where σ = volatility of the returns of the underlying asset, and N(d1) and N(d2) are the values of the standard normal distribution (mean 0 and deviation 1).

For the analysis of real options, the Borison method is classified as traditional real option methods, where the assumptions of this modeling approach are the same as the valuation of financial options. That is, we create a portfolio to replicate the rewards and risks of real investment opportunities and price the portfolio according to the no-arbitrage argument. Then adjust the portfolio based on investment opportunities.

Instead of treating risk as something to be avoided, the real options approach encourages managers to view volatility as a potential source of value, with profound implications for project design and corporate strategy.(Alex Triantis 2005)

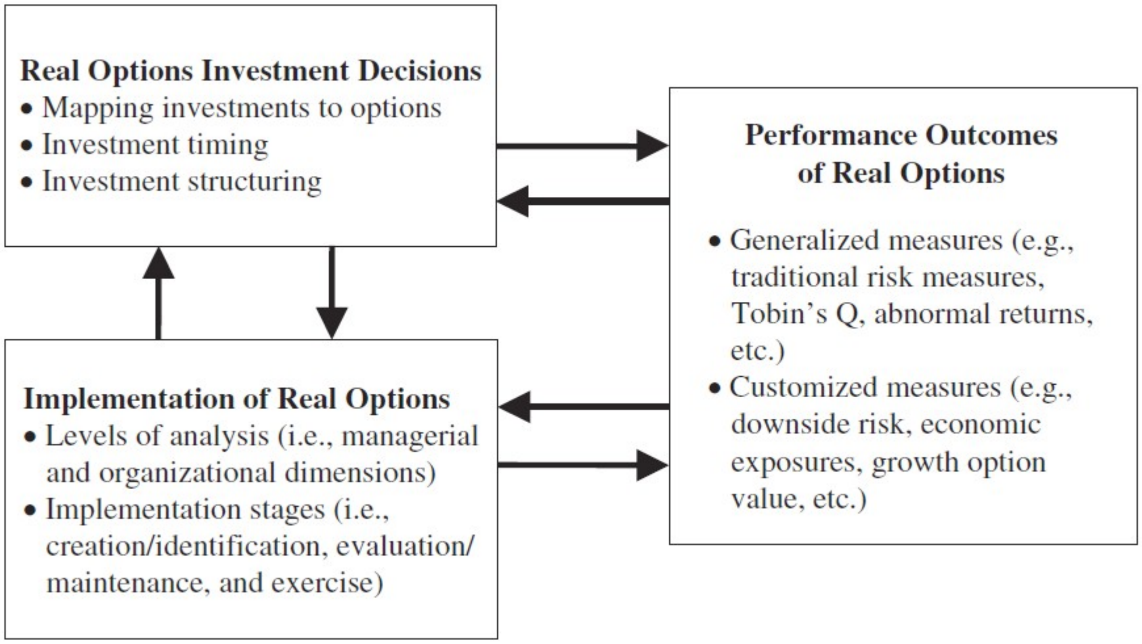
This use of replicating portfolios is commonly applied in the real options approach but the difficulty with this approach lies in being able to successfully replicate a portfolio, since it is almost impossible to think that we can replicate a portfolio that matches the risk of the company since it is unique with different variables that affect it. In this approach the covariance between real and financial assets is not considered. There is little empirical evidence to support the theory of portfolio replication matching firm risk. Taking this premise and in relation to the projects it is very difficult to apply and considering the randomness of asset returns that must also be replicated in the portfolio.

The first development of real options was done in 1986 by McDonald and Siegel with a valuation model of real options, and according to this approach the value of the project as the investment followed the geometric Brownian movement and to solve it, they assumed the setting of option prices. Something important in the RO approach is that it indicates that with greater uncertainty there are more opportunities or there should be a greater profit, which shows that for investors with a greater appetite for risk, an increase in uncertainty could increase the probability of investing.

This Real Options approach is perceived as a complement to the traditional analysis of the net present value of the free cash flow, since while the cash flow estimates a single possible and static scenario at the time of valuation, the Real Options recognize it is dynamic allowing to take different action strategies during the different stages of the investment project. This approach (RO) is ideal in high uncertainty environments, where decision making must be flexible and on the other hand,The Real Options, being dynamic and having different action plans in the different stages of the project, give an added value to the Net Present Value. and this added value is feasible to monetize or estimate.

The decision analysis approach involves a structured representation of the uncertainties and future decisions available to the decision maker. (Smith and McCardle [1998], Trigeorgis [1995]).

The Real Options approach, which is the subject of the Thesis, since having greater flexibility grants options for the successful development of the project, that is, it has possible additional courses of action that give greater value to the project, this is the added value of the real options approach.



Source: Framework for Real Options Research in Strategic Management.

Real Options can be defined using a mathematical logic approach to financial modeling with a more strategic perspective than traditional valuation methods, as it allows for dynamic project management.

Why choose Real Options for the valuation of oil projects?

Within the valuation of investments that are intended to be carried out, The Real Options are applicable in projects with high levels of uncertainty and being strategic financial options, allow better decision-making in the project, even more so in an oil investment project which it is multi-stage and can give these additional courses of action in in the different stages before and during the investment project.

The Real Options analysis complements the NPV but includes the added value of the active decision-making process throughout the life of a project, this makes it a strategic tool since it takes the flexibilities inherent in a project at the time your assessment and determine the value that consideration of this flexibility adds to a project. With this approach, the management capacity is given in the choice of optimal strategies once new information is obtained. As explained in the introduction, like financial options, a contract that gives a right to the buyer and an obligation to the seller. The application in real options would be the difference between the underlying asset that would be the investment projects, therefore in real options they are applied as the right, and not the obligation, to take the options in relation to the development of the project in its different stages. according to the interests of the investing company.

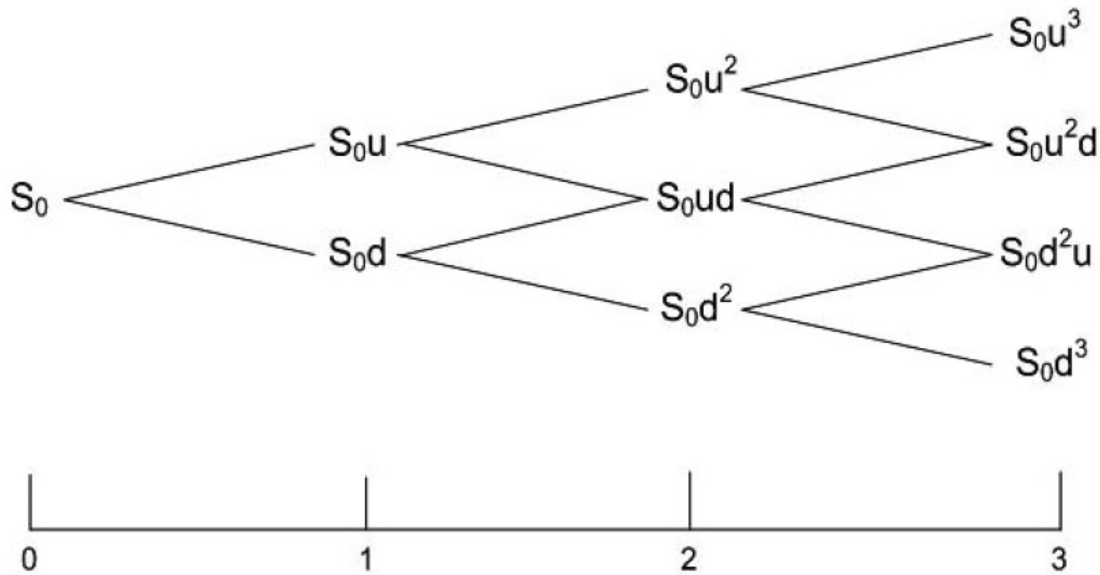
Binomial Trees

For this evaluation of the option associated with the increase in value generated by the flexibility and uncertainty. We must be able to quantify how each possibility or decision node contributes a new value to the project, in its different stages.

The Black-Scholes model was designed for European options, The Real options work in an analogous like American options, there is no fixed date of exercise. Choosing this binomial method allows us to observe the impact of variations in both volatility and the strike price.

Approximating the Black Scholes method, the binomial method increases its precision with respect to the number of time increments. (Koduluka & Papudesu, 2006).

In binomial trees like the finite difference method, the resolution complexity increases exponentially with the number of dimensions of the problem. Due to this, it has derived methods such as Monte Carlo simulation, introduced by Boyle (1977), to avoid the explosive growth of the size of the problem. This method developed by Cox, Ross and Rubinstein is based on simple algebra, but its simplicity is the most intuitive even though it is based on the Black-Scholes method.



A real options model will be used with the binomial method ,here the benefit of developing an oil extraction project is valued considering the future uncertainty of variables such as the volatility of the oil market price and the exchange rate.

Where St is the present value of the expected cash flows in t. The St value can take two possible values uSt and dSt ($0 < d < 1 < u$) with risk-neutral probabilities p and (1 - p), respectively.

This risk-neutral probabilities approach introduces risk by fitting future cash flows with the binomial tree with risk-neutral probabilities while discounting them at a risk-free rate.

A previously calculated price will be assigned and ascending, and descending movements will be generated in each node.

The binomial mesh is the value of the underlying asset independent of the option with the same properties, the underlying tree must start from the current price of the cash flows and this value is multiplied by the up

(u) and down (d) factors, obtaining uSt and dSt, and depending on the number of periods the process continues.

We can represent them by these equations:

$$u = \exp(\sigma\sqrt{\delta t})$$

$$d = \exp(-\sigma\sqrt{\delta t})$$

σ is defined as volatility (%) and δt is the time of each period of the binomial tree.

The risk-neutral probability is p

$$p = \frac{\exp(r\delta t) - d}{u - d}$$

r is the risk-free interest rate over the life of the option This method values models in discrete time, to simulate the cone of uncertainty of the underlying asset.

They state that the value generated by the flexibility, which is quantified by the option, must be compared with the NPV evaluation that would have been carried out without considering the value provided by the flexibility. They particularize that the value of a delay option increases according to the sunk cost once the option is exercised and with the level of uncertainty about future values. (Dixit & Pindyck, 1995)

Types of Real Options

Real Options are classified according to different types of flexibility and this flexibility of the project is applicable when there are multiple options, but it is important to point out that it is not the sum of these options separately, but rather the interaction between each one of them in the different stages or Phases of the Project which will be important for decision making.

Within the theory of real options, some options have been recognized that are frequently found in projects, such as the defer option, the sequential option, the increase, decrease or stop production, abandon option, and change option, growth option and compound options. (Schwartz & Trigeorgis 2001).

These are the types of Valuation options

Abandon Option

In our Oil Project we can rely on a negative NPV based on a conventional cash flow analysis where once started, the investment continues until the end of its economic life. Assets are quite high in cost and can be attractive in the used machine market. Therefore, according to the unfavorable loss minimizer theory, the firm could abandon the project before the end of its economic life, and sell the machinery used in the project and obtain a salvage value that is higher than the value of the project. the company in progress.

This option can be reflected like this:

Max (abandon value – project value, 0).

$$= VI + Max[VR - VI; 0] = Max[VR; VI]$$

The abandon option is a put option to sell the project for the salvage value, even if the present value of the cash flows is less than that amount. This abandonment option gives the project flexibility if the NPV of the expected cash flows is negative. The abandon option limits the negative exposure of the project:

In this scenario, the Project can be monetized at the redemption value or the abandonment option.

Shutdown Option

Now in this type of option for the oil project which has a variability component. In the process of operation, the main component of this investment, which is the price of oil, falls unexpectedly due to different circumstances unrelated to production, management has the option of avoiding operating losses through the temporary closure of extraction operations only limiting itself to minimal basic maintenance operations. Once the prices increase or at least reach the level that guarantees a positive balance estimated by the project management, the extraction operations return to their operational status.

We can reflect this option as follows:

$$= Max[A_1 - cVA_1; 0]$$

This is a call option with the price of oil equal to the variable cost.

When prices recover, production can continue. this option to temporarily stop a plant has the effect of truncating the lower cola of the net cash flow distribution

This option can be translated as limiting the losses due to the closing option and not participating in the transaction until there are positive operating margins.

Expand Options

Current market conditions do not even guarantee the continuity of oil extraction operations as the profit margin is slim with a slightly positive NPV or a negative NPV

But due to the flexibility of the NPV, this analysis does not take into account an expansion could be made if market conditions turn favorable. This option needs to be exercised only if the initial product is in demand or an increase in the price of a barrel of oil is forecast that will make a large positive net present value.

$$VP_1 + Max[wVP_1 - I_a; 0]$$

To find this value, the negative net present value of the first plant must be taken against the value that the growth option generates, materializing a new positive NPV investment if market conditions become favorable. We can summarize when current investments have the option of future investment opportunities, projects that might seem destined to fail can become viable.

For the project expansion option, we can define the value of option (c) and this is added to the initial NPV and the strategic NPV is generated. The strategic NPV can be defined as follows:

NPVe = NPV + c

That means at time 0 it is not known whether the project expansion option will be carried out or not, and it is related to future prices per barrel of oil or exchange rates for time n/2, so the acceptance of the project ppl can be graphed as follows:

NPV + c > 0

Flexibility

All investment projects depend heavily on uncertainty and volatility. Like risk, uncertainty is the variable that is imperfectly known, because of external variables, they can be costs of production factors, competition, political environment, demand, advances in technology, etc. The difference is that risk is the probability of each possible outcome happening, but uncertainty is the probability of that future outcome being uncertain.

With these definitions we will try to explain what flexibility is for the investor, how it influences decisions and explain how this additional variable contributes to the actions available to management in the project environment.

It is important to be able to assign a value to flexibility since it is not quantified in the number of available actions, but it is quantifiable in the profit that can be generated by being able to decide on one of these actions.

A real option only has value when there is a possibility of gaining something by exercising it. This can only occur when there is exclusivity in the option being considered, and during the period until the decision is made. The shared options that are usually originated by the environment or by the economic system do not provide differential value, except if there are clear and sustainable competitive advantages. (Gallardo & Andalaft, 2013, p. 53)

The volatility of this project, in this case of oil prices and the behavior of the market with the real options approach, will be considered flexibility, that is why its correct estimation, which in turn will give us a correct ROA approach. For this reason, the thesis will focus on the difference between traditional forms of valuation and real options, which is one of the main objectives of the work. How much is the influence and value that real options give to a project like this, and the difference of the thesis to present is the estimation of the volatility in the financial valuation of this project in a moment with high uncertainty and the possible adaptability that can or should grant the real options.

It is reiterative that the value that we are willing to pay for a project or investment must be consistent with the cash flows that it will return, bearing in mind that these have properties of both uncertainty and expected growth. (Damodaran, 2006)

Research methodology & data collection techniques

The two main possible variables that will affect our investigation are oil prices and the production profile, which affect the flexibility according to the uncertainty of the price of oil outside and the intrinsic complexity of the investment by volume of production, among others. variation which will be calculated and measured to what extent affects our assessment of the project

The fundamental variation experienced by the evaluation of investment projects through Real Options with respect to that carried out through traditional methods, is the incorporation of uncertainty as an element that adds value to the project. (*Dixit, Pindyck, 1995).*

This work will focus on the collection of secondary information sources, since due to the pandemic and the current travel limitations, it will not be possible to analyze the investment in situ; that is to say, go to the oil exploitation zones where the process of production and associated risks Another relevant aspect is that there is referential information on similar studies and projects carried out in other environments in which the type of investment and production processes are similar to the subsurface exploration project such as the one that is the subject of analysis in this thesis. Additionally, the limitations of accessing information due to blockades of specialized portals by foreign governments and the little disclosure of real data regarding the costs and expenses of a similar project, the estimates will be the closest to reality for the estimation of these variables.

For the thesis I will use the methodology of Cox, Ross, and Rubinstein of binomial trees. The first step is to evaluate the financial model of a hypothetical onshore oil field using the discounted cash flow method to find the present value, and then that model is compared to the real options approach. Within the model, one of the most important and deterministic variables is the price of oil. It is also a purpose of this study to delimit the analysis of the variable price of oil per barrel; This will be the variable that implies more risk and volatility to the valuation of the investment project.

To define the price per barrel of Brent oil, which in our case is one of the most important variables in the valuation of the oil project, several simulations will be made, and for this the daily historical series will be taken as samples from the year 1997 to the 2022 verifying that the yields of this asset are not behave normally until the period of April 2022 after that the most complicated part of the project will be the measurement and the sources to be able to take samples and possible future estimates of the price of oil taking into account the current world panorama.

Real Options theory is an application of financial options theory to real sector investments, such as investments in manufacturing plants, line extensions, R&D investments (Mauboussin, 1999)

A very important part of the Real Options approach is how to quantify the project. In my evaluation of this investment project, special care will be taken when assigning a value to the entire project, since this approach does not evaluate the flexibility of the total project. project but determines the values of each option or the flexibilities of each of the possible paths to follow in each of the stages of the project that we will evaluate. The methods that are usually used in the evaluation of an investment project similar to our project from the Real Options Theory approach are *the Black-Scholes method [Black & Scholes, 1973] and the*

Binomial method [Cox, Ross & Rubinstein , 1979], by means of which we will try to evaluate and generate a relevant contribution in the economic evaluation of the investment project with which the economic contribution or the value of each flexibility will be calculated as a set to the real value of the investment project.

In relation to international oil prices, we believe it will be the most important variable in this study. We have two references, the baskets of WTI (West Texas Intermediate) and Brent crude oils, and their importance lies in the assignment of a reference value for the negotiations of the rest. of types of crude allocated by the market in the world market. The Brent benchmark is the blended crude produced in the North Sea region that serves as a guide to set the price of a series of other crude currents (EIA. U.S. Energy Information Administration). The Brent basket is used in the main oil markets in the world, it also serves as a guide to crude produced and marketed in Russia, Africa, and Europe.

Currently, the world oil industry faces external and internal risks that make investment projects be affected in terms of production levels and price variability. For the analysis of the price variable, the Brent index (reference for crude oil prices) will be taken, which, although it is true that they are already set in advance for the coming years, will have significant variations during the estimation of this investment project.

In the methodology to be proposed, I will follow a sequential order for the valuation of the investment of the Project:

The first step I will the economic evaluation of the investment project using the Traditional Methodology. At this stage we will calculate the NPV of the project with the possible income generated by the project as well as the calculation of costs which will be valued at the project's own discount rate and the economic environment.

The second step consists of having the time horizon in which the Cash Flows, costs and operating expenses and main and secondary income that may occur during the evaluation horizon of the investment project will be calculated. Also, the residual costs, sunk costs, and possible residual income at the end of the useful life of the project.

In the third step we will identify and calculate the Real Options present in the investment project. Starting Diagram previously calculated we will be able to presence and temporary location of the Real Options of Waiting, Abandoning, Contracting, Expand. It is important to mention that each of these options will have a different value at each stage of the project, which could be evaluation, investment, production, and completion within the project's time horizon, which will allow a more realistic calculation within the evaluation of the project. investment.

Once the value of each of the options has been obtained, we will be able to assign a value to the Project by incorporating the value of the Options. In this work, we intend to use the Binomial Method with Logarithmic Transformation. The steps of the solution process of the Binomial Method with logarithmic transformation will be carried out, the calculation of the parameters of the project and the calculation of the parameters of the real options must be made. The Development of the Binomial tree will be used with the stochastic evolution of the project over time. And as a characteristic of the real options, the value of the project will be obtained with an inverse valuation process to value according to the variables and uncertainties of the project.

Finally, once the results have been obtained, they will be analyzed and the comparison will be made and the initial hypotheses of the thesis will be tested, we will be able to develop and contrast the characteristics of the Real Options approach as well as understand the possible implications of why this method is very used within the valuations of projects in the business environment.

Production cost (oil production and transportation)

With respect to the production curves, the minimum and maximum operating capacity of the new plant has been determined, so that no investments are required for the extraction and transport of crude oil, since it will remain below the capacity already previously installed.

The operational development plan of an oil extraction field must be planned according to the data provided by deposits, thus an estimated quantification of the oil and the investments required for this production is made, as well as determining the estimated amount to be sold. It is necessary to consider that the investment

We must take in consideration these two parameters

An important aspect to carry out the investment of a project is an external condition that guarantees the investment activities, for this reason the country risk will be considered when evaluating the project. The investment environment is very important and must be considered in the valuation of investments.

This variable would mainly affect the cost of oil production as well as the production of the project.

This aspect can be decisive for the success of a project, but we will assume that this environment will remain unchanged, and the calculation of this variable will be made according to the measurements made for the country risk as well as the market risk.

Volatility

There are many simulation tools but the one that best suits our projects is, with it you can find the sensitivities, volatility of the results and critical points of the project, to calculate the volatility of the project, it will be taken by applying the Monte Carlo simulation method of Copeland and Antikarov, taking the expected value of the uncertain

variables, and calculating the present value of the project at instant t = 0 (V0). The relevant uncertain variables of the project are taken as input elements in the CF simulation, each simulation calculates the cash flow and the present value of the cash flows at the end of period 1 (V1).
A random variable X is then defined as the logarithmic return of the project in the first period, the applied formula is shown:

$$X = Ln\left(\frac{V_1}{V_0}\right)$$

Project data analysis
To determine the project of an oil field, we must be able to estimate its market value, its usefulness and something important is to be able to compare it with other similar projects, is important to be able to determine these two components within the project operation project.

(Capex – Capital Expedition)
(Opex – Operational Expenditures)

CapEx = PP&E (current period) – PP&E (prior period) + Depreciation (current period)

Are important in order to have a broad overview of the investment and its possible returns, with the projected production values of all the wells in an oil field, maximum and minimum production levels can be calculated This will serve to calculate investments in infrastructure and the operating cost of fluid treatment, and the correct distribution of costs. Once the forecasts of production quantities have been obtained, the crude sales cost projections are calculated and with this future income is obtained.

An important characteristic in this type of projects is the behavior of oil wells, where after a certain time they begin to reduce the amount of crude oil that reaches the surface as the Project progresses to a level insufficient for extraction, which is why it is necessary be in a continuous drilling of new wells that can replace production.

The parameters

C = Call Option Value

S0 = Current Value of the Underlying asset

X = Investment Cost or “Strike Price”

r = Risk Free Discount Rate

T = Expiration Time

$d1 = [\ln(S0/X) + (r+0.5\sigma 2)\, T] / \sigma \sqrt{T}$

$d2 = d1-\sigma \sqrt{T}$

σ = Annual Volatility of the Future Cash Flows of the Underlying Asset.

N (d1) and N (d2) = Values of the standard normal distribution of d1 and d2.

Oil Project Evaluation

The schedule for the start and development of operations of the oil project based on the PMP approach (Project manager project).

Project Timing			
Base Year	2022		
Project Construction Start	10-Jan-22		
Notice To Proceed (Actual)	20-Feb-22		
Initial Supply Date	19-Jul-26	Facility Acceptance (per Projected Schedule)	15-Sep-26
Commissioning Period	92	Debt Conversion Date Certain (per Term Sheet)	30-Sep-26
End of Commissioning	19-Oct-26	Conversion Date	1-Oct-26

Period			
SPA Start Date	1-Nov-26	End of First Year of Operations	31-Dec-26

As we mentioned, the financial evaluation will be done through the discounted cash flow and then it will be done with the Real Options approach based on binomial trees. The first step is to evaluate the variables that can impact the success or failure of the project.

The financial model of the project using the discounted cash flow method to find the present value. At this stage, the flexibilities of the model will not be considered.

For the creation of this model, the analysis and calculations of the estimated production were made based on the production of a real oil field, as well as the transport calculations and the minimum and maximum production operational capacities, modeling a favorable scenario without setbacks attached tables

These are the variables that make up the model:

The initial investment in equipment is US$3,816,948 of the project will be made up in one part by its own capital and the other part will be through two loans of US$ 1.4 and US$ 1.3 million dollars.

Cost Project	Total	Percent
Debt	2,700,000.00	71%
Equity	1,116,948.00	29%
Total	3,816,948.00	100%

4 production wells will be opened and the cost of each is $ 263,745

The estimated cost of participating in the tender is $100,000 USD

Oil reserves will be exhausted in 20 years

Royalties represent 1% of revenue per barrel

The risk-free rate is 3.056 % per year

The tax rate is 30%

Debt Loan 1.3m

Amount	1,300,000		
Interest Rate Calculation			
Base Interest Rate			4.55%
Spread			1.20%
All-In Interest Rate			5.75%
Amortization Style:			
Mortgage Style = 1			2.37%
Equal Payments = 2			3.57%
Tailored Payments =3			0.00%
Active Case:			2.37%
Beginning Balance			1,300,000
Interest Payment			37,375
Principal Payment			30,852
Total Debt Service			68,227
Ending Balance			1,269,148

The country chosen for the investment of the project is Peru and within the important variables are:

Moody's rating : A3

Country Risk premium: 1.38%

Inflation rate : 7.96%

Is important mention the Country risk premium because this influences the measurement of the project

We must calculate the beta of the oil industry which will help us to carry out the calculations of the project

Beta (β) = 1.32

$$R_E = R_F + \beta * \left(R_S - R_f\right)$$

An investor will only materialize an investment if it has a higher return than the US treasury bond, the difference between the investment and the return offered by US treasury bonds is known as Market Risk Premium.

Since the project is developed in another country, we must adjust by adding the country risk premium, this varies from one nation to another and with this variation the expected return changes. As it should be, there is a greater return if at greater risk, with it the investor the country according to the risk and the profit that he wishes to obtain Weighted Average Cost of Capital (Brealey, Myers, & Marcus, 2012).

$$\text{WAAC} = i * (1 - ISLR) * D + R_E * E$$

The results are

CAMP =14.47%

R_e = 15.37%

Discount rate= 12.97%

Oil price and Dollar price

This is the analysis of historical data on oil prices and the exchange rate with a time series of 25 years.

As we can see in these graphs, we can be seen that the probability density of the random variables does not follow normality.

Modeling of the oil price

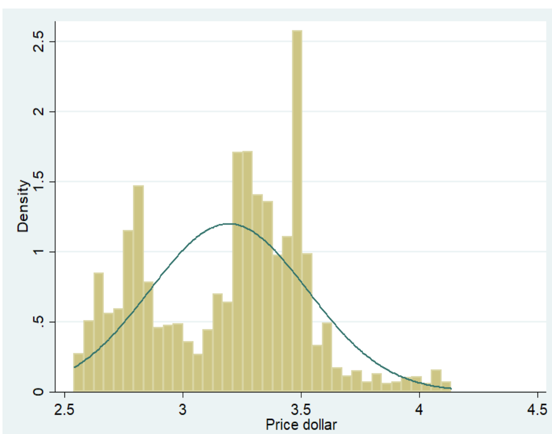
To model this variable within the investment valuation, we will take future oil prices that can be modeled following the geometric Brownian motion process, we will focus on the stochastic process in the oil price modeling approach.

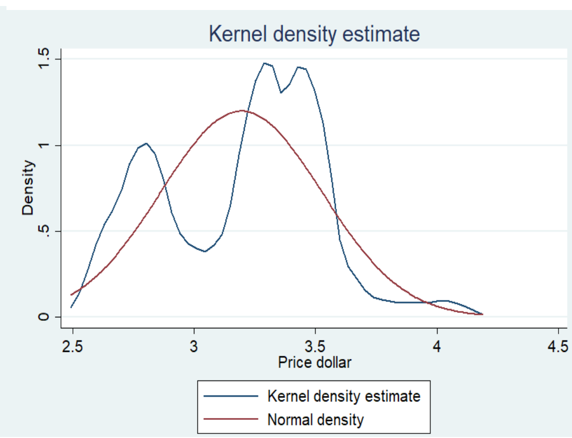
Geometric Brownian motion (GBM) is a process that is very often used to model future prices, which consists of a continuous-time stochastic model where the variable follows a drifting Brownian motion.

In this formula P is the Brent Oil price of US$/dollar and use a Wiener process $dz_p = \varepsilon\ p\sqrt{d}t$, where ε p is a normally distributed random variable with mean 0 and standard deviation 1, and variance and drift parameters.

$$P\ (t_{i+1})=P\ (t_i)\exp(\alpha_P\ \Delta t + \sigma_P\ (\Delta t)\ _{1/2}\varepsilon p)$$

Where:
P =Brent oil price
α P = drift
σ P = variance parameter oil
The financial model of the oil field is given in annual terms, the initial price of the Oil (P) is based on the calculation of the historical daily prices of the last 25 years, as well as the estimation of the mean (μ) and standard deviation (σ)





As I know in the graphs these show that the historical data do not show a normal behavior with a high peak that represents the probability of small variations and the tails the probability of extreme variations as well as a downward trend

.

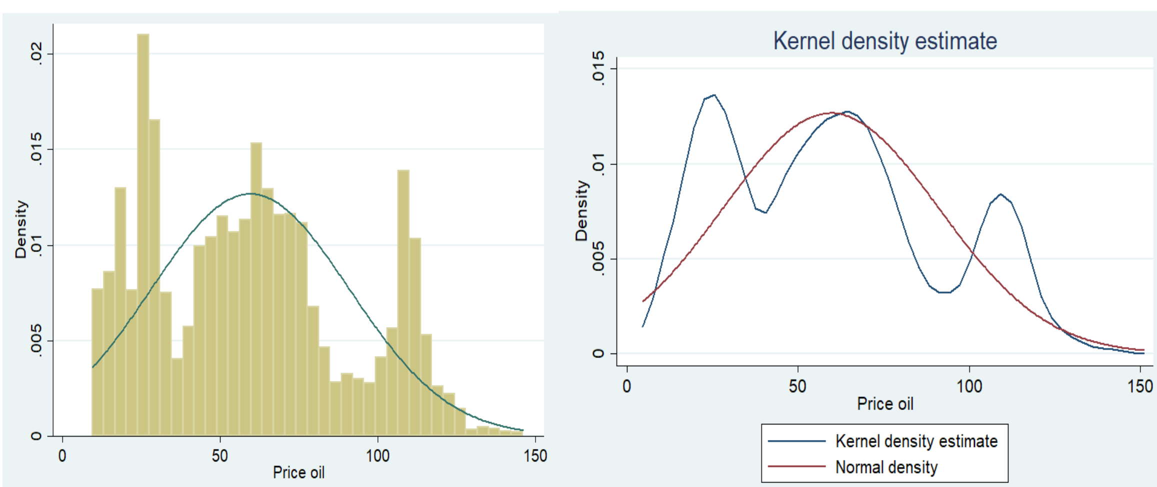
Modeling of the dollar price (exchange rate)

This is the other important variable that will be considered for the modeling of our financial evaluation of the oil field, also to model the exchange rate, we will take future prices of the dollar that can be modeled following the geometric Brownian motion process, we will focus on the stochastic process in the dollar price modeling approach. Geometric Brownian motion (GBM) is a process that is very often used to model future prices, which consists of a continuous-time stochastic model where the variable follows a drifting Brownian motion.

In this formula D is the exchange rate in Nuevo Sol (PEN) and the US dollar price and use a Wiener process $dzp = \varepsilon \, p\sqrt{d}t$, where ε d is a normally distributed random variable with mean 0 and standard deviation 1; and variance and drift parameters.

$D(t\ i{+}1) = D(t\ i)\exp(\alpha d\ \Delta t + \sigma d\ (\Delta t)\ 1/2 \varepsilon d)$

Where:
D = dollar price (exchange rate)
α d = drift
σ d = variance parameter oil
The financial model of the oil field is given in annual terms, the initial price of exchange rate (D) is based on the calculation of the historical daily prices of the last 25 years, as well as the estimation of the mean (μ) and standard deviation (σ) .



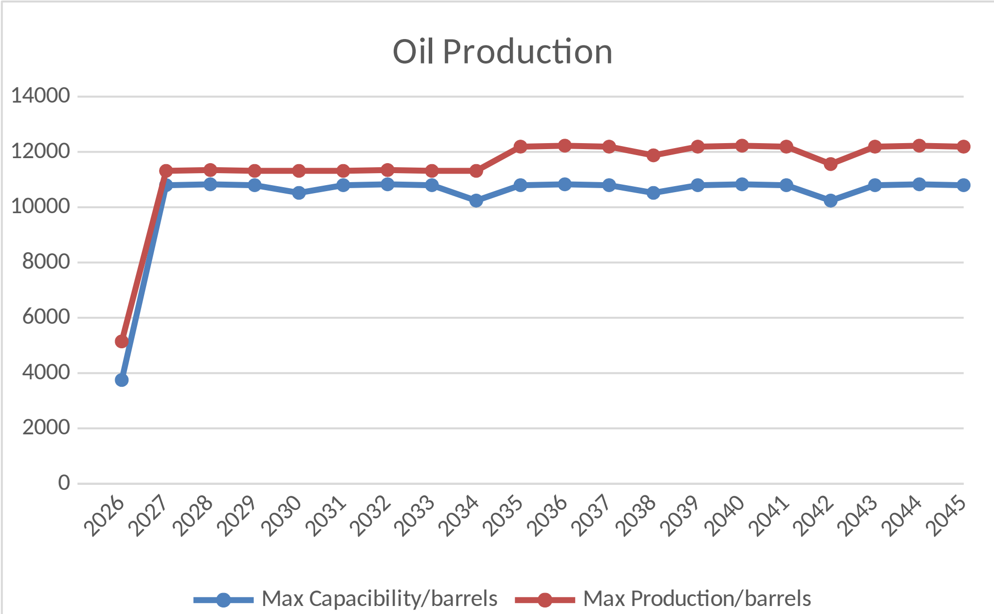
In this graph, the historical data shows a behavior with fat tails of extreme variations but with a probability of a lower rise as well as a higher peak in the low prices, which represents the probability of small variations.

To model the price of oil within our oil field investment valuation, we obtain fits this series (25 years) with the geometric Brownian motion, which is defined by these equations:

The correlation between both variables is very low

Oil production volume

The production volume has been modeled with the minimum and maximum production of the possible extraction volumes in an optimal environment, considering only the working days of the extracting country (Peru). The technical extraction criteria were modeled with 04 extraction fields and with a production of 83.3% of the maximum installed capacity in this document, the production variable will be constant and unchanged during the life of the project.



Plan Annual Production						
		1	2	3	4	5
Year		2026	2027	2028	2029	2030
Start of Year		19-Jul-26	1-Jan-27	1-Jan-28	1-Jan-29	1-Jan-30
End of Year		31-Dec-26	31-Dec-27	31-Dec-28	31-Dec-29	31-Dec-30
Days in Year		166	365	366	365	365
Total Scheduled Downtime		**0**	**0**	**7**	**0**	**16**
Unscheduled days downtime		45	17	10	17	10
Availability (days per year)		**121**	**348**	**349**	**348**	**339**
Availability Reduction (Sensitivity)		0	0	0	0	0
Active Operating Days	1	**121**	**348**	**349**	**348**	**339**
		121	348.34	349.34	348.34	339.34
GUARANTEED RATE CASE						
Guaranteed Inlet Rate	42					
Max Annual Processing Capa	50	5082	14630.28	14672.28	14630.28	14252.28

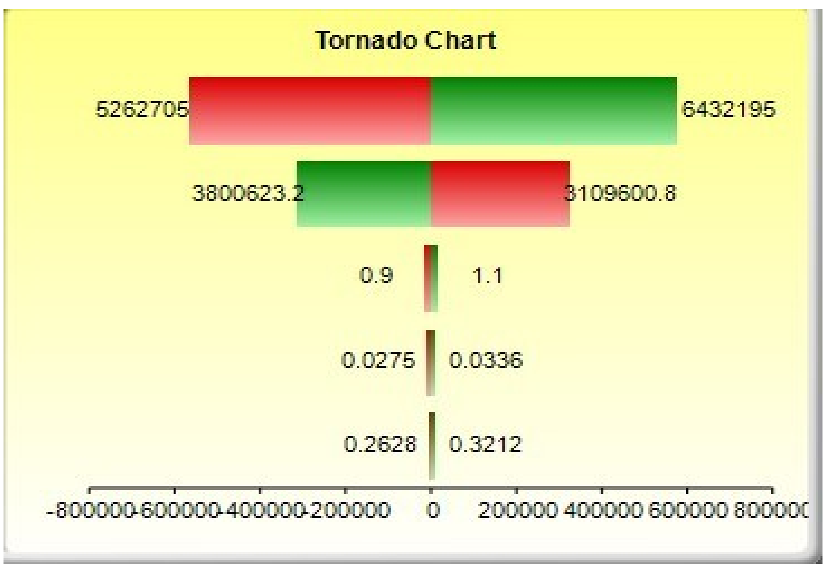
In this graph show that the production and transportation of oil remains constant during the development of the project.

Cost and Expenses

The investment cost of the investment project, these costs will be applied the first 4 years and 6 months according to the project schedule. The total investment cost is US$3,455,112

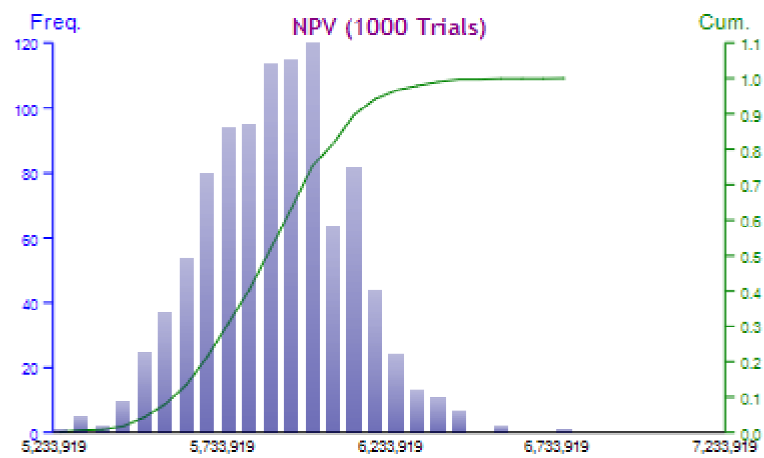
Period	1	2	3	4	5
Year	2022	2023	2024	2025	2026
Start of Period	28-May-10	1-Jan-11	1-Jan-12	1-Jan-13	1-Jan-14
End of Period	31-Dec-10	31-Dec-11	31-Dec-12	31-Dec-13	19-Jul-26
Plant cost	198,364	601,892	896,550	495,027	159,246
Pipeline expansion cost	10,711	154,500	394,813	198,452	3,055
Company management	60,116	41,025	66,735	46,071	22,795
Operations	0	9,234	36,968	42,027	17,531
Total	269,191	806,651	1,395,066	781,577	202,627

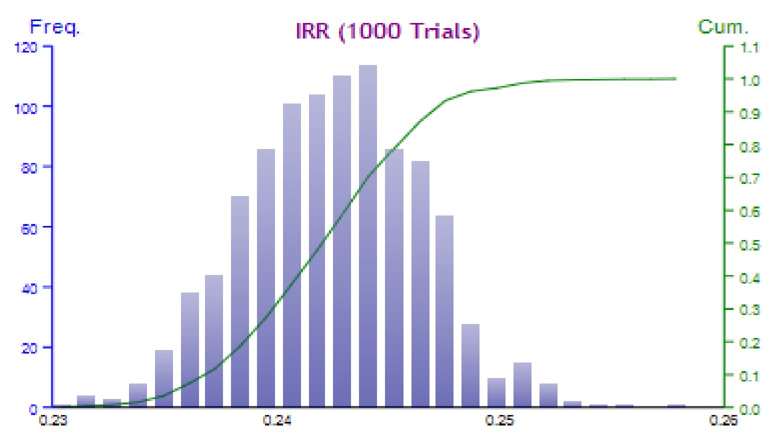
Cash Flow



Once defined, we can estimate the NPV of the project is US$ 5,915,867 and an IRR 32.59% of which shows that the project is profitable following the premise that the value of the NPV >0

Once the main effects of this model have been analyzed, it is stipulated that the level of production, as mentioned, will remain stable, there is no uncertainty regarding the presence of oil or problems with extraction and transportation, the capital structure has already been indicated and the leverage was carried out in the first years of the project.
Regarding the price of a barrel of oil, this is considered stochastic with high volatility, and it is the main uncertainty that greatly affects the financial evaluation of the model, while the exchange rate variable has less volatility within the financial analysis.





Binomial Tree

For the estimation of the binomial tree, the following variables were calculated:

Assumptions

PV Asset Value ($)	$5,847,450.00
Implementation Cost ($)	$3,455,112.00
Maturity (Years)	1.00
Risk-free Rate (%)	3.06%
Dividends (%)	0.00%
Volatility (%)	29.20%
Steps	24

Intermediate Computations

Stepping Time (dt)	0.0417
Up Step Size (up)	1.0614
Down Step Size (down)	0.9421
Risk-neutral Probability	0.4958

Oil Project

Call option

										10612666
									9998588	
								9420043		9420043
							8874974		8874974	
						8361444		8361444		8361444
					7877629		7877629		7877629	
				7421808		7421808		7421808		7421808
			6992362		6992362		6992362		6992362	
		6587765		6587765		6587765		6587765		6587765
	6206579		6206579		6206579		6206579		6206579	
5847450		5847450		5847450		5847450		5847450		5847450
	5509101		5509101		5509101		5509101		5509101	
		5190329		5190329		5190329		5190329		5190329
			4890003		4890003		4890003		4890003	
				4607054		4607054		4607054		4607054
					4340478		4340478		4340478	
						4089326		4089326		4089326
							3852707		3852707	
								3629779		3629779
									3419750	
										3221874

Oil Project

										7218601
									6608843	
								6034611		6025979
							5493852		5485229	
						4984643		4976016		4967380
					4505215		4496543		4487891	
				4053994		4045186		4036449		4027759
			3629672		3620562		3611596		3602754	
		3231267		3221616		3212186		3202972		3193957
	2858168		2847687		2837481		2827570		2817967	
2510132		2498528		2487206		2476211		2465590		2455384
	2174259		2161519		2149071		2136983		2125333	
		1860905		1846740		1832831		1819269		1806171
			1570018		1554130		1538395		1522919	
				1301890		1284016		1266104		1248251
					1057156		1037134		1016782	
						836760		814613		791752
							641849		617882	
								473595		448480
									332917	
										220128

These are the results for the binomial tree for the first 11 periods and This estimate of the underlying asset tree (NPV) for the 10 years, as shown in the following Figure the maximum value if it increased in a proportion of 1,0661 would be 20991892.15 The value of the option is 2510132.45

Abandon Value Analysis

In this type of project, the greatest value of an oil field is its reserves, which can only be negotiated together with the operating infrastructure as a business model. This particularity of this type of extraction projects does not handle salvage values of the equipment since they are totally specialized for this project and the reserves cannot be negotiated outside their location.

Intermediate Computations

Stepping Time (dt)	0.0417
Up Step Size (up)	1.0614
Down Step Size (down)	0.9421
Up Probability	0.4958
Down Probability	0.5042
Discount Factor	0.9987

The abandonment of an oil project can be due to several factors, both operational and profitability.

If this option is chosen by the management where, in the case of the project, it would be its value according to the valuation literature of the abandonment option, a salvage value equal to the expected NPV of the oil project is determined in the node of the binomial tree in which the option is exercised.

You may have a valuable option in exchange for its salvage value (Trigeorgis, Real Options and interaction with financial flexibility, 1993)

This result the NPV is added, and we have the total value of the project in which the flexibility of abandoning it in the project in the period that this option is convenient to exercise is included. This total value is 5861412.28

Continuing with the same analysis of the abandonment option, as can be seen in period 16, it becomes zero, that is, greater than the exercise value

In conclusion, only in completely unfavorable periods for the project will the abandonment option be exercised from period 14 when the value is >3,455,112.

Expansion value analysis

Within this option, as previously mentioned, the project has 4 wells and, seeing an upward scenario, it is considered to expand the operating capacity of the plant by increasing a new extraction well.

cost expand	263,745.96
% production	10%
Factor exp.	1.0961

For them, I calculate the expected increase in the production of the new well and the additional costs that would be incurred for its execution, considering that the processing and transportation capacity of the oil.

The value of the expand option is 6157735.80 and it is possible to execute to period 19.

Discussion

The results unexpected variation of the price of the dollar also has a negative impact on the value of the oil project. Therefore, in oil investment with foreign capital in a currency other than the country where it is invested, they are affected when variations in the exchange rate occur, since the investment risk increase.

The model concluded that the application and observability of this variable for an evaluation of oil investments with different currencies in the country of investment is convenient to make a more precise evaluation.

The Black-Scholes equation is widely used in the valuation of financial options due to its easy implementation; it turns out to be very useful in the valuation,

Binomial trees have a great advantage since they allow a transparent analysis due to their theoretical framework, this makes an intuitive and easy to understand scheme although the complexity of the method increases exponentially as well as the dimensionality of the project.

The results show a high valuation in the expansion option if conditions such as the price or the exchange rate become favorable, since the costs associated with the investment of expanding capacity are very attractive. In addition, the ability to adapt production plans depending on new environments can change the project profitability.

Conclusions

The oil investment evaluation case is a complex process that has an inherent risk, and several uncertainty factors play an important role in the successful evaluation of large-scale projects like this one that allow us to appreciate the benefits of real options.
The application of this approach can be implemented in all fields, but in projects with high uncertainty the benefits of RO can be better appreciated.

Using historical data, the volatility of these variables affecting the project and their probability distributions were determined stochastically, with oil being the variable with the greatest impact. The volatility of oil is uncontrollable and depends on international prices.
In our analysis the exchange risk can be underestimated, but this variable can impact the success or failure of the project this variable behaves with less volatility.

Identifying and measuring risks and opportunities is a key factor for decision making and we must adapt to these changes. It is worth mentioning that OR does not replace traditional methods such as cash flow discounting, but it is a more sophisticated evaluation technique that acts as a complement, both techniques are a much more precise tool in valuation projects since the traditional way of valuing projects through the VPN assumes a single scenario without flexibility. This Flexibility is the strategic element in Real Options.

The use of OR maximizes the value of a project in all its stages. It increases the initial valuation integrating its flexibility and volatility in the face of possible changes. This approach allows continuous control of the status and scope of the project, being able to adapt to changes in the economic environment, allowing the application of options to maximize profitability.

We can conclude that applying the binomial tree model, the implicit value of the real options approach is obtained.

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