Master's Thesis

Oil and Gas Projects: A Decision Under Investment Risks in a Landlocked Country

by

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Certification of Originality

I, ATEM Lino Gabriel Warkuk (ID 52116618) hereby declare that the contents of this Master's Thesis are original and true and have not been submitted at any other university or educational institution for the award of degree or diploma.
All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

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ATEM, Lino Gabriel Warkuk

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Summary

This research work focused mainly on the oil and gas industry by analyzing Risks that expose investment decisions to risk of deteriorating outcome. There are many Risks that complicate investment decision when it comes to allocating capital expenditure for new project in oil and gas industry, extant literature focused on “oil prices, exchange rates and investment environment". In this thesis, producing country’s location has been considered for further research investigation by questing answers for research questions pertained to the impact of landlockedness on project investment decision, my research look at the transit cost per barrel as a factor that could diminish revenue for oil producing landlocked countries.

I have deployed Monte Carlo simulation for independent variables as mentioned in the previous paragraph to calculate and forecast cash flow and investment project net present values to evaluate the project paths that carries more risk. South Sudan has been used as case because it meets the criteria of oil and gas producing landlocked country. three standard oil field sizes have been considered for detail comparative analysis with specific analogy when transit cost is included in the evaluation and when the transit cost is not included in the valuation. In the exploratory data analysis, the transit cost is weakly and negatively correlated to NPVtr, oil prices, production cost but portly correlated to forex exchange rates. The results have shown that when transit cost is added to investment project evaluation procedures, the investment risk is quantifiable and tends to be 56%, 49.5% and 27.21% paths abandoned. While in the case where the transit cost is omitted in evaluation, the paths abandoned tends to be lower. The implication of transit cost can be observed and reflect in competitive disadvantages that landlocked countries endure due to the geographical locations.

In Summary, transit cost has an impact on project evaluation, transit cost decrease NPVs across the three oil fields sizes. Country fiscal regime is affected when it comes to foreign exchange reserve management, high transit cost diminishes revenues hence it affects the reserve which can be observed in exchange rates fluctuation.

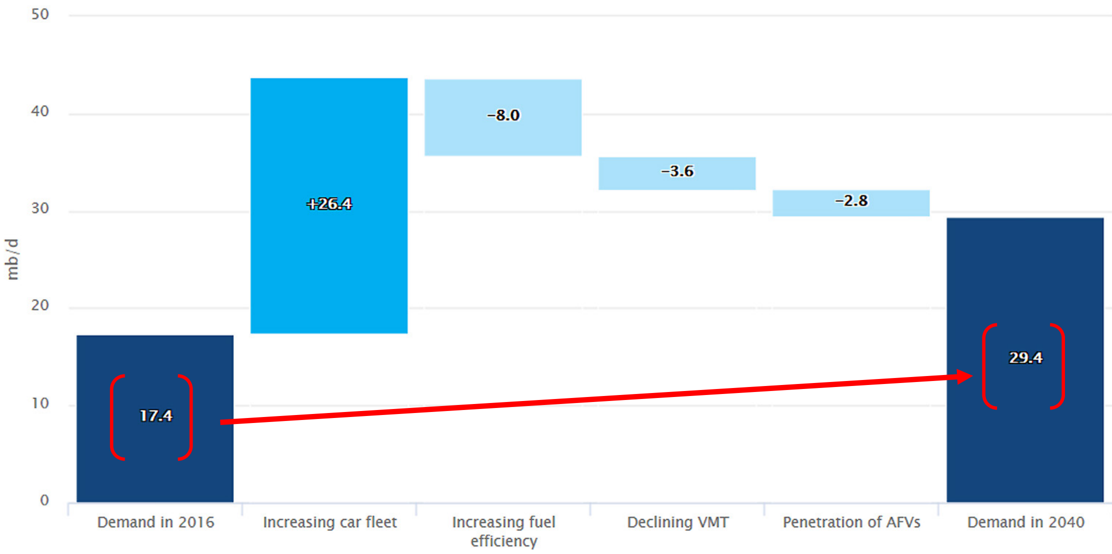
Chapter_1: Introduction

1.1. Oil and Gas Industry Background

The energy has become an engine of growth since steam engine invented during the industrial revolution in Britain in the mid eighteen centuries. Since then the world has become an energy hanger. The crystal reason lies behind the logic that; every aspect of human progress is a function of it energy it consumes efficiently, under this assumption, the quest for energy had led to extreme exploitation of every sources wherever possible to meet the demand. Oil and gas industry is considered the most important bases of energy in the world, it fuels the world economy and it has its geopolitical impact as well. It is worth mentioning that oil and gas industry is a depletable resource, oil and gas reserve is characterized with life cycles that ends with noncommercial quantities to exploit; this mean that an oil well when it has a proven reserve, that reserve can be extracted if proven it holds an economic value, otherwise it might be put into standstill due to the lack of economic viability

Generally, the scarcity of oil and gas sources based on the premises that oil and gas reserves are geographically located around the world in specific areas, this exhibits that most of proven reserves are located where the demand is low while the countries that have higher demand have low reserve of oil and gas like china and India. This made some developing and developed countries try to consider searching for more energy sources where the reserve is placed, by investing abroad in exploration and resource development. From oil and gas industry outlook, it is apparent that the demand for the oil and gas around the world is driven by chemical industries and transportation sector as it exhibited the Fig 3.18 from OPEC website(OPEC, 2016) it tells that the demand for oil and gas will be increasing due to the number of car fleets increase from 17.4 to 29.4 millions barrels per in developing countries

Figure 3.18 - Demand in road transportation in Developing countries, 2016 and 2040



Source: OPEC Oil and Gas Outlook, 2016

Furthermore, price of oil and gas is one of the most fluctuating commodity prices, but the investment capital required for projects and period for construction is hard to determine, the project life cycle is too long and hosting environment is also a critical factor, all these factors make every aspect of investment decision process a complex task to handle by investor.

The Risks are not limited to what have is mentioned above, but the location of the producing country intensify difficulties to investment decisions, some oil and gas reserves are in a politically unstable region, however, it is a resolvable situation in short or long-term. But the concept of location goes beyond that; the countries that have proximality to international market have more advantages than those countries don't. many initiatives have been initiated in UN conventions, multilaterals and bilateral initiatives to address the issues of trade corridors for landlocked countries. The Geneva Convention 1882, international maritime law in 1982 and the results of UN third convention constitute the sources of jurisprudence in the matter, these discussions have address challenges faced by landlocked countries. Therefore, this thesis treats landlockedness as a source of disadvantages that can jeopardize decision pertained to investment apart from Risks.

Oil and gas industry has three divisions which depend on each other, there is "Upstream", which consist of exploration and production, while "Midstream" is made of storage, transportation, and "Downstream" is typically concern with refining the crude oil and converting it to final products. The industry structure has a competitive environment across values chains, it has key players or companies in three main division upstream, midstream and downstream, those companies have a powerful existence in the industry internationally.

These companies are categorized into three types: integrated oil companies, it is a type of companies that are private in nature but highly and vertically integrated in the industry, known as "International Oil Companies" also known as IOC like BP, and Exxon Mobil. Another type is National Oil Companies (NOC), they commonly exist in the regions of Organization of Petroleum Exporting Countries "OPEC" like Nile Petroleum Corporation also known as (Nilepet), Nigerian National Petroleum Corporation and Saudi Aramco. There is another type of corporations, they are typically Russian and Chines companies that hold major operation in oil and gas industry in international arena like (CNPC, SINOPEC and CPECC). Furthermore, there are more oil and gas organization specialized in some specifics operation and activities in the industry value chains.

1.2. Government's Roles in Oil Producing Country

The hosting country in form of its government, has a critical role in oil and gas industry, this role come in framework of its' consciousness to ensure that there is an economics rent that would captured for the benefit of the citizens. For government to control the industry, it must introduce some tools, procedures, for instance, reasonable taxation that attract investors to take risks in exploiting the resources.

Moreover, the role of government is apparently observed in petroleum laws and regulations that maximize profits for the government and payoff for investors as well, given the fact that government is a key shareholder in investment projects by default

Furthermore, government puts special fiscal systems arrangements, there are three classifications; First, Production Sharing Agreement, secondly Service Contract Agreement, and thirdly what is known as Tax Royalty Agreement, each of these types of oil and gas contracts are carried out between the investing companies and the hosting government, and each carries different types of economies rents. These control mechanisms have strong significant impact on oil and gas investments. South Sudan is the subject of our case in this thesis, the type of petroleum fiscal regime follow the Production Sharing Agreement interchangeably know as Production Sharing Contracts, in some countries exploration and production are combined and called exploration and production sharing agreement. each of these contracts has advantage and disadvantages, the same types of contracts can differ as well based on each country according to (Bindemann, 1999; The International Institute for Environmet and Development, 2012)

1.3. Research Background

This research focused mainly on the impact of location of oil producing country on investment decision. It is worth mentioning that, the Risks are distributed across those structures mentioned among the industry players. However, my thesis looks at "Upstream" Risks under the assumptions that there is a proven reserve to be exploited.

1.4. Research Questions

In the light of the previous section of this chapter 1, It is apparent that there is a near link between location of country and decision taken pertain to investment, the previous research questions revolved around the impact of tariff cost and time management in for import and export of good for a landlocked countries, in this research present there of questions sought to be answered, there is a lack of clear understanding as to what extend do the landlockedness impact investment decisions, therefore, the following questions were develop to establish a research answers thorough investigation.

1.4.1. How Transit Cost/Fee impact different sizes of oil and gas the investment projects? In this question the method is trying to calculate Net Present Values given the Risks of input variables based on Mote Carlo simulations

1.4.2. How investment risks (the % of abandoning a project) vary between a landlocked country and non-landlocked country given the same Risks?

1.5. Thesis Structure

The rest of chapters is organized as follow, chapter_1 addresses the literature in the subject matter by focusing on what has been researched so far on investment Risks in oil and gas industry, threads of work done on methods specially the application of real option theory and Monte Carlo Simulations, in addition to literature that took discussions on concept of landlocked countries. In Chapter_3, the focus is on methods used for computations, and how results are evaluated and the procedures involved. In Chapter_4, the thesis concentrates on data presentation, variables classification, Monte Carlo Simulations results, and data analysis and discussion, while Chapter_5 presents general notes on conclusion, managerial implications, recommendations and further research.

Chapter_2: Research Literature Review

2. Introduction

The literature review of this research draws intensively from a series body of research that streams from three areas of concepts; oil and gas investment Risks, landlocked country as risk in investment project evaluation and real option analysis that will be used in next Chapter 3.

2.1. Risk factors in oil and gas industry

Oil and gas business mainly consist of Upstream made up of exploration, investment appraisal and field development, while Downstream consist of transportation, refining and distribution, each of these phases embedding Risks. Basically, there are Risks that stand as an obstacles which make the investment payoff in the industry risky in term of capital irreversibly, risk in future value of investment and risk in timing of initiating the investment(Dixit & Pindyck, 1994). Generally, there had been a great deal of literature review which discussed risks and Risks in oil gas industry, my research considers four types of Risks. The risk in this thesis follow as per definition provided by (Knight, 1964) and elaborated by (Roggi, 2014) whereby the definition expands the concept of risk by categorized it into measurable and non-measurable risks, and this where the think deference between risk and uncertainty are differentiated.

2.2. Oil Price Risk

First, oil price is as one of the Risks because it fluctuates by dropping and rising across the time series dimension which make it not easy to predict future cash flow or revenue, therefore it was used in studies that investigate volatility and evaluation of "oil and gas investment projects" in the following research work (Dixit & Pindyck, 1994)(Michael J. BernnanSchwartz Eduardo S., 1985)(Henriques & Sadorsky, 2011) and (Blake & Roberts, 2006) applied the oil prices factor to compare petroleum fiscal regimes like royalty tax, PSC, ROT and hydride system that involves PSC and ROT . This research thesis follows the strand of work which suggests that the crude oil prices follow a Geometric Brownian Motion according to (GBM)(Pindyck, 1999).

2.3. Exchange Rates Risk

The Second risk, is the exchange rates for the hosting country or the country of the foreign companies that brings in the financial resources to the investment projects. Since exchange rate is characterized with volatility like oil prices, the forecasting of exchange rates follow Geometric Brownian Motion(GBM) and affect the value investment of the project according to (Dixit & Pindyck, 1994), some other empirical studies have been done on the research that confirm the impact of exchanges rates on oil investment projects(Tang, Zhou, Chen, Wang, & Cao, 2017)(Fan & Zhu, 2010a).

2.4. Oil Production Cost and Investment Capital

Thirdly, oil development cost is an risk driven by fluctuation of inputs or material prices in the hosting oil producing country, this has been thoroughly described as a proxy to CPI which reflects the status of construction material prices in the country, this mean that when the CPI frequently changes, it affects the cost of oil development(Fan & Zhu, 2010b), therefore the investment environment is represented by oil development cost and CPI as per research conducted by (Zhu, Zhang, & Fan, 2015). This thesis considers it as important input for analyzing oil and gas investment projects. According to (Dixit & Pindyck, 1994), developing oil and gas project requires hug flow of capital, however, deploying the capital is uncertain and the time it takes to construct the project is also uncertain. In my research, the time of project completion is known due to the effect of learning where the repeated actions in project construction reduce the duration by 1%-3% (Mályusz & Varga, 2017), therefore, we consider time of completion as uncertain, but the capital flow for initial investment following diffusion process, it will be discussed in greater detail in methodology chapter 3.

Since oil and gas requires huge capital at various stage of its development; it is paramount that oil and gas companies should do an informed analysis that capture comprehensive Risks involved in the process of evaluation whether a national operating company that represent the hosting country, or a foreign national company. The Risks (oil prices, exchange rates and oil production cost) that have been reviewed so far to reflect the existing body of knowledge related to my research. However, my thesis suggests a forth factor to be part of investment project evaluation as in the following section 2.5 of this chapter 2.

2.5. Producing Country's Landlockedness

The forth factor is the location of the oil and gas producing country, it is technically termed as Landlockedness(UN-Ohrlls, 2013). Being a landlocked country(LLC) carries some disadvantages of not able to access international market easily except through non-Landlocked/Coastal countries, this disadvantages or constraints have been well documented as an issue that critically deprives LLCs economic growth(Faye, McArthur, Sachs, & Snow, 2004). Even though the LLCs have constraints due to its landlockedness, there had been a debate and discussion to resolve this complexity in favor of LLCs as per UN treaties that allow free access to sea pathways through coastal countries which has been summarized in(Uprety, 2006).

It is worth noting that there are almost total of 44 landlocked countries around the world, 10 of them are oil and gas producing countries, what they produce constitute approximately 4.37% per cent of world daily total production of crude oil, some of them have proven reserve not exploited yet, it is foreseen that many of them face or already have issues in regard to trans-border pipelines with transit countries according to(Dimitroff, 2014), these countries are South Sudan, Chad, Uzbekistan, Kazakhstan, Azerbaijan, Turkmenistan, Kurdistan[1] , Uganda, Democratic Republic of Congo and Afghanistan.

As far as landlockedness is concern for oil and gas industry, there have been hurdles that are reported in regards to the impact of landlockedness to oil revenues for some landlocked countries, specifically, a thorough steam of research was conducted in this

[1] Kurdistan still not an independent state yet, but it is managing the operation of exporting crude oil(Uprety, 2006)

regard, but it focused on the negotiation aspect of the cross-border oil and gas pipeline between the producing country(LLC) and the transit country/coastal country, the same line of research also answers the questions of ownership arrangement, sharing of the pipeline project benefits among the parties involved and the economics of the transit fees is also discussed (Omonbude, 2013).

From industrial application aspects, there has been projects that involved cross-border oil and gas pipelines, the best illustration is between Sudan as a transit country/Coastal country and South Sudan as an oil and gas producing country which is a landlocked country(LLC), another case is Chad-Cameroon pipeline project, both projects involved transit fees being applied to allow the crude oil pass to the seaports of the transit country, not limited to that but also Uganda has potentially agreed to pay a transit fee to Tanzania for the usage of pipeline for crude oil export (Report, 2016)(Republic of Chad & Griffiths Energy, 2011)(Reuters, 2016).

In summary, previous literature in academia circles and industry practice, justify that landlockedness is a factor that has an impact on the project economics, furthermore, landlockedness which represented by 'transit cost', is a factor that diminishes revenues depending on the interplay of other Risks. What this research is trying to do, is to add the landlockedness to the arrays of existing Risks (oil prices, exchange rates and “development cost) that encounter oil and gas in upstream. The next subsection discusses and present previous literature of approach that will be deployed to evaluate the Risks of oil and gas upstream.

2.6. Real Option Approach Theory & application

Real option theory is one of the decision theory body of knowledge that is deployed for conducting an evaluation of an investment project in many various fields to support managerial decisions. It has been one of important areas that took a significant share of pie in both theoretical and application research as well. Real option was first introduced to finance domain by Myer stating that an investment decisions related to corporate assets can be reviewed based on the future value of investment projects therefore it follows the Call Option(Myers, 1977). Since then the research and application of Real option approach evolved and spilled over many fields. According to (Michael J. BernnanSchwartz Eduardo S., 1985) the real option approach is preferred to the conventional method of net present value NPV technique because it captures the volatility of the output like prices and the related polices in case of natural resources investment.

2.6.1. Real Option Analysis(ROA) scope of application

In practice, real option Approach(ROA) which is interchangeably termed real option analysis(ROA) gives the rights of decision making to an investor or investment project key players under investment risk, it allows them to exercise strategic decisions that involves Call Option, the core idea behind the real option approach is to provide flexibility when financing an investment project; this flexibility can be categorized into 6 option of choices defer, abandon, switching, Alter operation, growth option and staged investment(Lander & Pinches, 1998).

While the ROA was primarily used in finance sector for equity market valuation, there have been an intensive researches geared towards Real Option Approach(ROA) in other 16 areas, not limited to finance and natural resources but it includes areas ranging from human resources to corporate strategy(Lander & Pinches, 1998). This research follows the threads of work that have been developed on the application of Real Option Approach(ROA) to the natural recourses investment analysis, however, there are some closer empirical researches to the thesis which were conducted to evaluate copper mining, oil and gas projects ,(Dixit & Pindyck, 1994),(Mcdonald & Siegel, 1986). According to(Fan & Zhu, 2010a), the real option has been used by applying to compare the oil and gas investment based on the variables (prices, exchanges rates, and investment environment) among producing countries by using closed framework solutions, while other related research work has used the same variables but with exception of investment environment replaced by oil development cost to assess the investment projects overseas, by applying monte Carlo Least Square Method(LSM))(Longstaff & Schwartz, 2001). However, this thesis applies Monte Carlo simulation and Least Square regression according to(Zhu et al., 2015) and (Pindyck, 1999) with four Risks (oil prices, exchange rates, oil development cost and landlockedness).

Furthermore, the previous research tried to build a multifactor model that considers different types of Oil and Gas development contracts for the investment projects valuation. In a nutshell, this thesis will use the term real option Approach/Analysis (ROA) throughout the document with specific concentration on oil and gas investment project evaluation to construct a solution framework that capture a multifactor risks to study the impact of landlockedness of a producing country on the project investment valuation in oil and gas industry by deploying Monte Carlo Simulation

As a way of summary, this thesis scope does not cover technical feasibly of investment project, rather it sheds light more on the impact of the landlockedness on evaluation in case where the oil and gas transit cost are considered and another case where the producing country is not a landlocked country.

The next chapter will be focusing on the construction of framework based on the real option Monte Carlo to simulate the investment evaluation in a landlocked country given exogenous cost of trans-border pipeline transit cost.

Chapter_3: Research Methodology

3. Introduction

The research method of this thesis is designed around key questions that have been posted in introduction chapter 1 of this research. This Research applies risk identification tools by deploying standard Geometric Brownian Motion to simulate the three input variables for the time frame 2016, namely; international oil prices, forex exchange rates for the investee country or the hosting country and oil development cost. Least Square Monte Carlo Simulations is used to run the analysis for real option valuation, while South Sudan is considered as a case due to its landlockedness, however, the method is applied as well when the hosting country is not a landlocked country to compare the level of investment risk for each case.

3.1. Analytical Framework

The purpose of this chapter is to present the analytical framework and to prepare the necessary data required to conduct the analysis to measure the risk associated with the input variables at a given time which is referred to as 2016 in this research. Furthermore, the section will conduct a case study by applying the approach to a landlocked country. Normally the oil and gas projects are divided into construction phase; where the capital is highly required to developed the production facilities while operation phase is for extraction of the crude oil proved reserve(SPE, 2007)

The goal of this research method chapter 3, is to construct a framework that would measure the possibilities of abandoning an upstream oil and gas projects, given the Risks and the location of the investment hosting country or in different term, the landlockedness of the oil and gas producing country. the sections in Chapter 3 is organized as follow: 3.1. Analytical framework, 3.2. Project Evaluation procedure.

This section is elaborating on various Risks factors that will be calculated through a computer aided simulation by deploying Python Programing Language(Zope Corporation, 1990), has been selected for its unique capabilities in handling computations and the sets of libraries that entails the modules suitable for this research. Most importantly, it is an it is an open source software that does not need commercial adds-on which makes it good for academic research comparing to other programing languages like MATLAB.

In a nutshell, the analytical framework will be implemented as follows, the initial values for the Risks are simulated to generate sets of data structures which known as pandas in python like matrix shape but it holds a typical table shape. The analytical framework addresses the Risks regarding investment projects under the assumption that there is a feasible proved reserve of crude oil. Moreover, the investment valuations will be conducted in sub-section 3.2 of this chapter.

3.1.1. Risks Simulation

Since there are several Risks in oil and gas industry that dictate the investment decisions, it is paramount to mention that this thesis focuses on covering "risks and Risks upstream division of oil and gas" as it has been highlighted in Chapter 1. While there are many types of risks in each sections of petroleum industry in Upstream, midstream and downstream, this research sheds light on upstream Risks which can be summarized into geological risks, political risk, economics risk and environmental risk according to(Clews, 2016). However, this research is addressing economics risks in upstream and its implications, the cost that comes from midstream for trans-border pipelines for a landlocked country which represent not only the transportation aspect of the oil and gas industry but a complex required infrastructure that expands and cross borders internationally with financial implication(Omonbude, 2013). The following four Risks have been considered for the analysis in this thesis. In the following Risks explanation, (T) annotation refers to total time required to build and operate the oil and gas investment projects; however, the project is divided to several periods to ease the, evaluations as new data arrives for each period, Δt is the time step required for the evaluation and N=T/Δt represents number of steps in each simulation path.

3.1.2. Crude Oil Prices

The international fluctuation of crude oil prices plays a key role in investment project decisions, in addition, it makes it not smooth to accurately predict the future prices using moving averages forecast, the essence of risk in crude oil prices, however there is a consensus that the movement of international prices follow stochastics process in form of geometric Brownian motion(Pindyck, 1999) and it's formula can be written as follow.

$$dPr_{Cr} = \mu_{Pr} Pr_{Cr} \Delta t + \sigma_{Pr} Pr_{Cr} \Delta z \tag{1}$$

From Eq (1) it is observed that the geometric Brownian motion(GBM) characteristics is well articulated; where Pr_{Cr} is the forecasted international price of crude oil quoted in USD/barrel, α_{Pr} , σ_{Pr} are the drift rates or the expected growth rate and the variance for the crude prices respectively in a time series manner, while Δz is an independent incremental wiener process that add the volatility or randomness behavior to the to the GBM formula which is broken down into $\Delta z = \varepsilon\sqrt{\Delta t},$ where Epsilon ε represent normal distribution of mean 1, and standard deviation of 0 which can be put mathematically put as N(1,0). However, since Eq (1) will be used for investment evaluation, it better to include crude oil price risk premium into equation 1, hence the equation would be as this

$$dPr_{Cr} = (\mu_{Pr} - \alpha_{Pr}) Pr_{Cr} \Delta t + \sigma_{Pr} Pr_{Cr} \Delta z_{pr} \tag{2}$$

The risk premium (μ) for crude oil prices is an annualized as result of investment risk-free rate (r) and expected annual growth (α_{Pr}) for crude oil prices. When applying the Ito lemma process when $X = \ln(Pr_{Cr})$ the equation is as follow.

$$dX = \left(\mu_{Pr} - \frac{1}{2}\sigma^2 - \alpha_{Pr}\right) \Delta t + \sigma_{Pr} \Delta z_{pr} \tag{3}$$

But with some application of algebra manipulation the following formula will be as a result for discrete approximation of GBM for this research is as this following equation

$$Pr_{Cr}(t_{i+1}) = Pr_{Cr}(t_i) \exp\left[\left(\mu_{Pr} - \frac{1}{2}{\sigma_{Pr}}^2 - \alpha_{Pr}\right)\Delta t + \sigma_{Pr}\varepsilon_{pr}\Delta t^{0.5}\right] \quad (4)$$

3.1.3. Crude Oil Lifting/Production Cost

Assessing investment environment is somewhat troublesome to calculate, therefore, Production cost is considered as a proxy because it is one of various costs that involved in facilitating extraction of the crude oil from oil wells in upstream of the industry(Fan & Zhu, 2010b). The Risks in this cost element is tight to the changes in material cost. This risk is driven by consumer price index of materials that goes into construction of oil and gas projects. It follows GBM to reflect the business environment for the hosting or the oil producing country since it not normal to incorporation some recognized business environment rankings like world bank doing business reports(The World Bank, 2017), however this thesis follow the threads of research that use cost factor as GBM variable that suit this research(Fan & Zhu, 2010b; Zhu et al., 2015), and by applying the procedures as in the previous risk in Eq(4), the resulting equation is as follow:

$$C_{Cr}(t_{i+1}) = C_{Cr}(t_i) \exp\left[\left(\mu_c - \frac{1}{2}{\sigma_{Pr}}^2 - \alpha_c\right)\Delta t + \sigma_{Pr}\varepsilon_c\Delta t^{0.5}\right] \quad (5)$$

Where, $C_{Cr}(t_{i+1})$ is the predicted cost, $C_{Cr}(t_i)$ represents the initial cost input and μ_c α_c,are the expected rate of growth and risk premium related to the production cost derived from consumer price index(CPI)

3.1.4. Currency Exchange Rates.

The currency exchange rate is a key risk that follow GBM as well. The impact of Exchange rates is reflected in the fiscal budget of the producing country when it pays overseas payment for procuring material and acquisition of services related to oil investment projects. Furthermore, Since the producing countries consumes their forex reserves for the aforementioned activities, hence, the exchange rate has an impact on fiscal budgeting since the oil revenues will be converted to the producing country currency according to(Bodart, Candelon, & Carpantier, 2015; Fan & Zhu, 2010b).Therefore, It is paramount to reflect it in the model. By applying Ito lemmas as in Eq (3), the final formula is as follow:

$$Ex(t_{i+1}) = Ex(t_i)\exp\left[\left(\mu_{Ex} - \frac{1}{2}{\sigma_{Ex}}^2 - \alpha_{Ex}\right)\Delta t + \sigma_{Ex}\varepsilon_{Ex}\Delta t^{0.5}\right] \quad (6)$$

Here the $Ex(t_{i+1})$ is the expected value of forex exchange rate, $Ex(t_i)$ is the forex exchange initial value input and μ_{Ex}, α_{Ex} are the expected growth rate and risk premium for the forex exchange and σ_{Ex} is the variance for the currency growth rate.

3.1.5. Projects Investment Capital

The investment in oil and gas project is no exception when it is about investment under Risks for natural resources related projects. It is an irreversible capital allocation practice, that would require exceptional decision procedure, irreversible investment in oil and gas projects and minerals is characterized with hug sunk cost that cannot be recovered if put into use, it has a sunk cost behavior according to (Dixit & Pindyck, 1994), the formula in this kind of investment follows jump diffusion process where the cost of the project is considered uncertain, this imply that the financial resources required to be used as an expenses in each stage of project construction tends to be uncertain as well, in addition to the time of project completion. However due to the learning effect of the operating companies in South Sudan, it has become apparent from the oil companies that it is possible to plan oil and gas projects while time of completion is known to some degree(Mályusz & Varga, 2017), unlike when the contractors have no learning effect experience . Therefore, the formula for cost required for completing the oil and gas projects is estimated with diffusion process as follows:

$$dK_{Inv} = -I_{inv}dt + \beta[I_{inv}K_{Inv}]^{0.5}dx \qquad (7)$$

Where, β is the investment risk related to investment total cost (K_{Inv}) according to (Dixit & Pindyck, 1994; Zhu et al., 2015), I is the initial investment for the initial required cost to complete the project and dx = $dt^{0.5}.\varepsilon$ is the wiener increment process with ε as the random variables normally distributed at mean 0 and standard deviation 1 , the discrete form for the formula is as follow:

$$K_{inv}(t_{i+}1) = K_{inv}(t_i) - Idt + \beta[I_{ti}K_{Inv}(t_i)]^{0.5}dt^{0.5}.\varepsilon \qquad (8)$$

This formula estimates the probable yearly remaining cost to complete the project, the result is subtracted from total cost K_{inv}, the resulting matrix is a yearly project expenditure I values, each path of 5000 has a set of I value.

3.2. Investment Project Valuation Calculations

This section deals with oil and gas projects valuation. The valuation is based on main three concepts that are technically interrelated and affect each other's outputs. The following subsection deals with the concepts and their solutions methods

3.2.1. Investment Cash flow

The cash flow in oil and gas is dependent on many variables based on the type business concession or in more specific; cash flow calculation depends on the types of contracts; some countries follow Resources royalty tax while other use production sharing contracts. This thesis utilizes production sharing agreements since it is relevant to the case of South Sudan and the general equation is as follows:

$$\mathrm{CF}(t_i) = [Pr_{Cr}(t_i) \cdot \left(Qr_{Cr}(t_i) - (Qr_{Cr}(t_i) - cl_{oil}) \cdot g_{govt}\right) - C_{Cr}(t_1) \cdot Qr_{Cr}(t_i)] \cdot (1 - Tax_{inco.}) \cdot Ex(t_i) \tag{9}$$

Where $\mathrm{CF}(t_i)$ represent the cash flow of oil sales after the investment project is completed while the right side of the equation is as follow:
and subtraction of oil cost limit and government shares respectively (cl_{oil} & g_{govt}), and $(1 - Tax_{inco.}) \cdot Ex(t_i)$ is a combination of corporate income tax subtraction and forex exchange rates at the time of sales. In contrary, since Eq (9) is meant to evaluate the oil and gas project related to investing companies portion which is considered as a foreign operating companies(FOC) in the case of South Sudan, the Eq (7) could be manipulated to address the hosting government economic rent in the investment projects, hence the formula could be modified and formulated as this:

$$\mathrm{CF}(t_i) = [Pr_{Cr}(t_i) \cdot (Qr_{Cr}(t_i) - (Qr_{Cr}(t_i) - cl_{oil}) \cdot g_{FOC}) - C_{Cr}(t_1) \cdot Qr_{Cr}(t_i)] \cdot (1 - Tax_{inco.}) \cdot Ex(t_i) \tag{10}$$

Where, g_{FOC} is the share in percentage for the foreign operating company, also known as (FOC). Each of equations (9& 10) could be used to assess project valuation for hosting government and FOCs as well. In this research the evaluation is done on FOCs as an investing agency.

3.2.2. Transit Cost Per Barrel

This subsection is the central point to the thesis due to its adverse roles in diminishing the revenues gained from oil sales both by the producing landlocked countries and the investors as well. The formula to capture cost implication of the landlockedness can be written in the following form.

$$\mathrm{CF}(t_i) = [Pr_{Cr}(t_i) \cdot \left(Qr_{Cr}(t_i) - (Qr_{Cr}(t_i) \cdot cl_{oil}) \cdot g_{govt}\right) - C_{Cr}(t_1) \cdot Qr_{Cr}(t_i)] \cdot (1 - Tax_{inco.}) \cdot Ex(t_i)] - ll_c \cdot Ex(t_i) \qquad (11)$$

The Formula for the cash flow would like this:

$$\mathbf{CF}(\boldsymbol{ll_c}) = [\mathbf{CF}(\boldsymbol{t_i}) \cdot \boldsymbol{Ex}(\boldsymbol{t_i})] - \boldsymbol{ll_c} \cdot \boldsymbol{Ex}(\boldsymbol{t_i}) \qquad \mathbf{(12)}$$

The rationale behind not imbedding the transit cost under the cost of production it is because of its' exogeneity to the petroleum fiscal regime, ll_c is the cost that is associated with transporting the crude oil from the landlocked country to through a second or a third country with purpose to access international market through seas ports as it has been highlighted earlier in Chapter 2. The point of the evaluation in this context, is to assess the impact of the transit cost on the project evaluation.

Since the transit cost ($\boldsymbol{ll_c} \cdot \boldsymbol{Ex}(\boldsymbol{t_i})$) is an exogenous element as it expressed in formula (12), it is not possible to include in the mina formula of Production sharing Agreement Contracts, that is why it treated separately and deducted only when all specifications of formula (12) are fulfilled.

3.3. Project Operational Value/Company Value

The project operational value, is the calculation of the cash flow for the life cycles of oil and gas projects which can be estimated to be around five years or less after the project has been constructed according to (Zhu et al., 2015), the formula is as follow for project investment value:

$$PV(t_i) = e^{-r(t_n - t_i)} * CF_i \quad (13)$$

The value of the investment to some extend can be viewed as $PV(t_i)$ when construction of the project is completed. The r is the free interest rate, in this work, interest rate has been considered as risk free rate, the compound interest rate $e^{-r(t_n - t_i)}$ assume that the project will be in operation indefinite till the oil resources diminish.

3.3.1. Projects Investment Value

The project investment value is calculated using NPV given Risks from the project investment cost, the time has been derived from conceptual design for wells(DPOC, 2016), the following equation has been deployed to calculate the NPV at two different situation (i) when the project has no transit cost associated with its production and *(ii)*when the project is located in a landlocked country like South Sudan. The goal is to quantifying the risk that transit cost could create, given a multi risk factors like oil prices, exchange rates and production cost and investment cost Risks. Here is the formula

$$NPV = PVCF_i - PVI_i \quad (14)$$

Where, "$PVCF_i$" is the present value (PV) of cash flow from the oil sales, while $PVI_i$is the present value for the investment capital for the period related to construction time in years. It's 14 wells per years, which makes it 1 one-year time for small size oil field, 3 years for medium oil field size and 4 four years for large size oil fields project.

The decision is based on estimating the option of abandoning an investment projects given the Monte Carlo simulations, the procedure is to identify the paths that does not payoff for the continuation option followed by finding the averages paths failed to meet the net present value (NPV) value at each given path; the average result constitutes the quantification of risks associated with transit cost resulted from landlockedness of the producing country, in this case it is referred to as South Sudan.

3.3.2. Project Paths Abandoned

The simulation generates 5000 paths as mentioned in above section, after doing forecasting computation procedures for oil prices, exchange rates, production cost and initial investment capital, the Present Value is calculated using standard discounted cash flow (DCF), after that the values of initial capital is factored in to obtain Net Present Values(NPV).

To calculating number of paths or projects failed to meet NPVs, python code is used process NPVs and Project Initial cost matrixes with NPV rule. The paths that do not meet the rules are counted and stored in matrix, the matrix is computed with total paths to obtain the percentage of failed paths for the three sizes of oil fields. This constitute a base to answer question 1 and 2.

In a nutshell, the comparison has been taken across two dimensions, first, there is comparison where two state have been analyzed (*i*) application of risk factors before transit cost included in the calculations which represent a situation of a non-landlocked country, (*ii*) And application of risk factors when transit cost is applied. Another dimension of comparison is by taking three standards oil and gas investment projects, namely; Large Oil Field, Medium Oil Field and Small Medium Fields as suggested by previous studies by(Blake & Roberts, 2006; Zhu et al., 2015).

3.4. Numerical Solutions Procedures

The solutions follow the sequential steps developed in (Zhu et al., 2015) in order to calculate project values, however with some modifications to cater for the new variables involved in this research.

1. Estimate Geometric Brownian Motion (GBM) parameters for four variables; oil prices, production cost, exchange rates and project cost

2. Calculate twenty-five 25 years and 5000 Monte Carlo paths matrix shape(pandas) data structure for the four variables
3. Calculate cash flows by substituting the values from step 2 into Eq (10 &11), in addition to calculating cash flow with transit cost by using Eq (9), the result will be a matrix of expected cash flows for next twenty-five years 25 simulation in 500 paths from 2016 to 2040
4. After that, the cash flows are discounted before and after the transit cost included to obtain Present Values for both scenarios based on Eq (13)
5. Calculate the Net Present Values (NPVs) by applying the initial investment costs from Eq (11) & Eq (14) for the three oil fields sizes (Large, Medium and Small)
6. After obtaining the NPVs across the 500 paths, the project is evaluated by estimating the NPVs that do not meet the NPVs standard rule. The number of failed paths will be abandoned and their percentage is computed through Python 3.6.5 conditional loop.
7. Comparing the abandoned paths in the two scenarios; and that before the transit cost and after the transit cost included in the evaluation.
8. Conducting multivariate regression analysis to estimate effect of variables on NPVs results.

In summary, this chapter 3, has been devised to evaluate the impact of landlockedness represented by oil and gas transit cost. The computation is run through python programming language for its unique computer memory management and rich library that suit the math in finance field. Monte Carlo simulations and NPVs rules has been deployed to make the analysis.

The next chapter 4 is structured to exhibit results, however the discussion and of the result will be highlighted as well.

Chapter_4: Data Analysis and Discussion

4. Introduction

This chapter 4 elaborates on variables, parameters estimation, calculation and results analysis. After going through the methods in the last chapter 3, it is paramount to exhibit the results that helped in building the framework for evaluating the impact of transit cost/landlockedness on oil and gas projects. This chapter 4 is arranged as follows; Data arrangement, case information, variables, Monte Carlo simulations and results interpretation

4.1. Data Arrangement

The Data was gathered from many sources as indicated in the following Table1 This table explain the type of data required, their sources and time frame of the data, the year 2016 was selected due to the stability data accessibility across the four input variables.

Table 1: Data Sourcing

S/N	Data ID	Data Sources	Timeframe	Remark
1	Oil Prices	OPEC basket	2016	Available
2	Exchange Rates	Bank of South Sudan Publication	2016	Available
3	Oil Production Cost	International Energy Agency Reports/Govt of South Sudan	2016	Available
4	Landlockedness Cost/Transit Fee	South Sudan Ministry of Petroleum Documents	2016	Available

4.2. Case Information.

In this research, South Sudan has is considered as a case to demonstrate the impact of transit cost because it is a landlocked country. In more details, the case will consider three types of oil fields as it has been studied previously by (Blake & Roberts, 2006; Zhu et al., 2015). The table below summarizes the case information used in evaluating oil and gas projects. The number of wells were calculated based on the daily average production of crude oil in South Sudan which is 600 bbl./day as per conceptual design for 2016(DPOC, 2016), this production's properties meet only the export specifications which is 10% water cut[2]. The government shares were obtained from Exploration and Production Sharing Agreement (EPSA)(MPM, 2000).

Table 2A: Fields sizes data

Field Size	Num. of wells	Daily Production Barrels	Annual Production Barrels	Fields Percentage	Govt shares In barrels	FOC shares in barrels
Large size	56	33600	12096000	57.14%	967680	11128320
Medium size	28	16800	6048000	28.57%	483840	5564160
Small size	14	8400	3024000	14.29%	241920	2782080
All wells	98	58800	21168000	100.0%	1693440	19474560

Source: Analysis, Appendix 1

4.3. Presentation of variables

The data in this research is categorized into three; independent variables, these are the data required to estimate parameters which is used in Geometric Brownian Motion (GBM) as indicated in research methods, this includes, for instance historical data for the year 2016 for oil prices, forex exchange rates, production cost per barrel and the initial investment capital for oil and gas projects. Another set of variables is, dependent variables resulted from independent variables through monte Carlo simulation procedure. Table 3 summarizes the parameters for the four variables as follows:

[2] This 10% water cut is the minimum percentage of water content for each barrel's sales exported through Sudan.

Table 3: Independent variables Parameters

Variables	Investment Risk (β)	Volatility (σ)	Mu (μ)
Oil Prices	0	0.50	1.35
Production Cost	0	2.31	0.63
Forex $/SSP	0	0.23	4.15
Investment Cost	0.5	0	0

Source: parameters calculated from times series data for the variables, Appendix 1

In a nutshell, the Table 3 values are derived from historical data for oil price, consumer price index(CPI), forex exchange , the investment cost was set in previous studies by (Dixit & Pindyck, 1994; Zhu et al., 2015), the method is documented in Appendix 1 which contains all procedures followed to reach the results.

4.4. Monte Carlo Simulation results

The appendix1 documents all the details of each step of calculation procedures involved to obtain the full probabilities of each variables as shown in the following charts. It is a simulation process of 500 paths across operational life of the project that is set at twenty-five 25 years as an expiration time of the oil fields.

Figure 1: oil prices simulation result

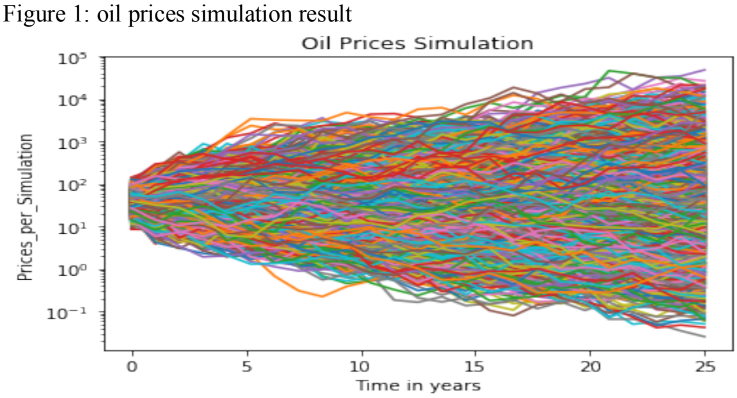


Figure 2: forex exchange simulation results

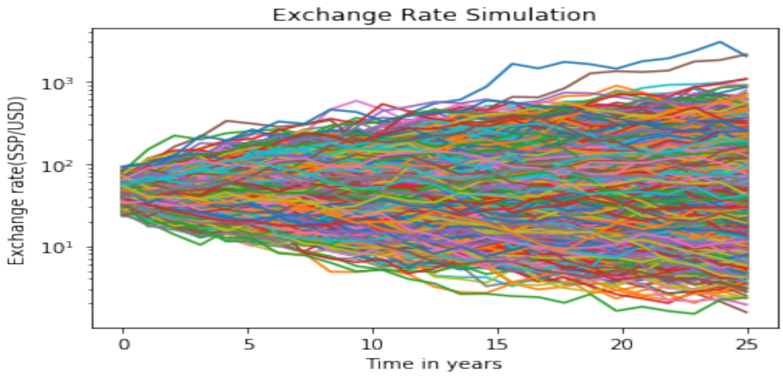


Figure 3: Production cost simulation

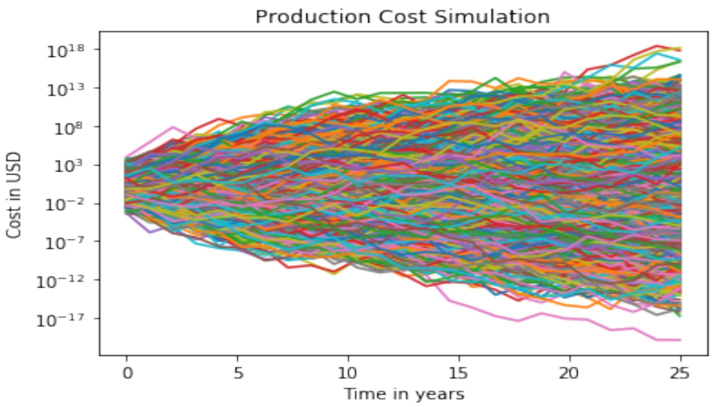


Figure 4: Investment capital simulation for large size project

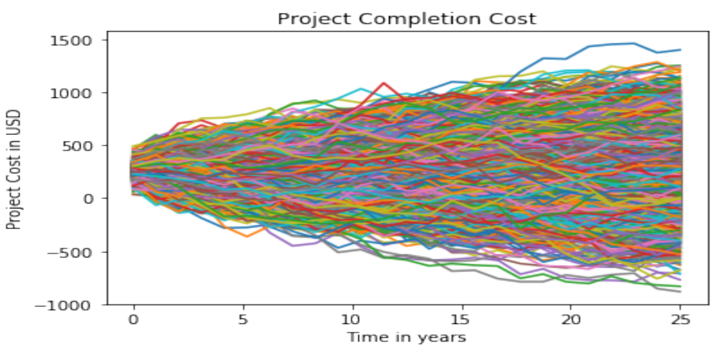


Figure 5: Investment capital simulation for medium size project

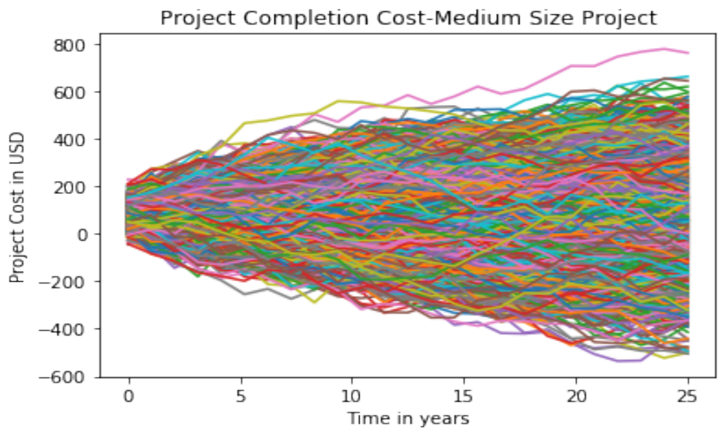
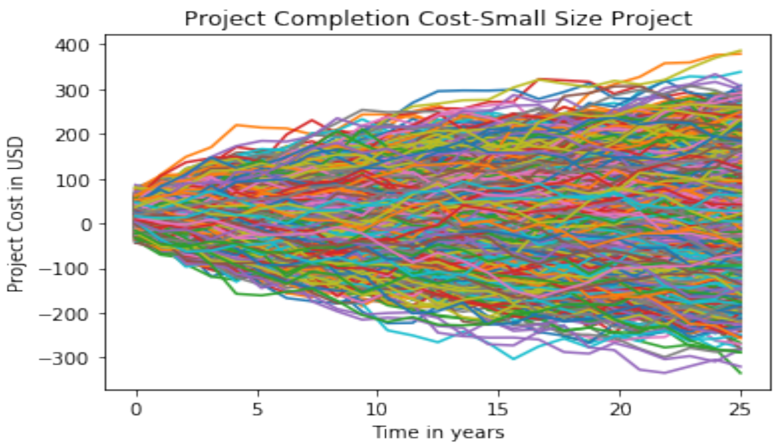


Figure 6: Investment capital for small oil field size project



The simulation above, generated a data that has been controlled by the inputs for the Geometric Brownian Motion, the variables have been stored in python data structure forms namely; pandas data structure, it takes shape of matrix but it does not follow matrices behavior during the computation. The unique feature of python data frame is that, it facilitates the computations by running the operation elements-wise, which suit the calculations when estimating NPVs for 500 paths and 25 years cash flows. Since it is so spacious to put all the tables of the simulated data here, the appendix 1 contains snapshot of those variables resulted from simulation using Monte Carol Simulations.

4.5. Result Interpretation

4.5.1. Descriptive Statistics

This section elaborates on the descriptive statistics for the variables associated with the figures (1 & 6). It summarizes the number of population, their mean value, standard deviation values for the variables, in addition to quantile values.

Table 4: Variables Descriptive Statistics

	NPVtr Large Projects	Oil Prices	Forex Exchange Rate SSD/USD	Production Cost	Transit Cost
count	5000.000000	5000.000000	5000.000000	5.000000e+03	5000.000000
mean	5554.106709	289.369890	67.388394	4.073850e+08	640.189740
std	28360.622299	1988.527636	64.029258	1.203820e+09	608.277947
min	-1965.589638	1.252981	6.672885	2.262880e+07	63.392407
25%	-500.042010	19.160926	31.687281	1.341523e+08	301.029165
50%	642.966405	49.225299	48.833505	2.305194e+08	463.918302
75%	3860.989849	147.275713	79.706855	4.101633e+08	757.215124
max	997068.632386	70526.035233	989.088389	5.852118e+10	9396.339698

Source: Appendix 1

4.5.2. Variables Correlations

The figure 7 reflects how variables are correlated across three sizes of oil and gas project according to the description provided in the case. the black color represents weak correlation while light color based on the color bar in the plot shows strong correlations among variables.

In Large Size Oil Field correlations, when the transit cost is considered during the evaluation, the correlation can be interpreted as follow:

- The NPVtr is positively and strongly correlated to the prices of crude oil at value of +0.97, this would make sense since the increase in prices increase the cash flow through sales, hence the impact could be observed in project net present value. However, the NPVtr is negatively and weakly correlated to forex exchange rates with value -0.012, this could be accredited to the fact that, in oil and gas industry, the sales transactions are carried out in US dollars, however the negative correlations are due to impact of oil revenues on local currency, it can be inference that greater NPVtr is mainly drawn from cash flow, which means more profits hence the foreign exchange reserve level can be considered to some extend to be increasing but not significant as far as this variable reflects.

Moreover, the NPVtr is also weakly and negatively correlated to production cost at value of -0.006, the negative correlation gives an insight that when NPVtr increase the production cost tends to be decreasing, this goes down to the causal impact of production cost on cash flow and present value of oil and gas investment projects.

- Most importantly, NPVtr has a weak and negative correlation at -0.012 with transit cost per barrel produced and transported via trans-border and gas pipeline, what is most interesting about this value is the negative correlation, it reflects that core of what the thesis is trying to figure out, the interpretation that can be drown is that; the transit cost has no statistics significant, but apparently it is diminishing NPVtr values.

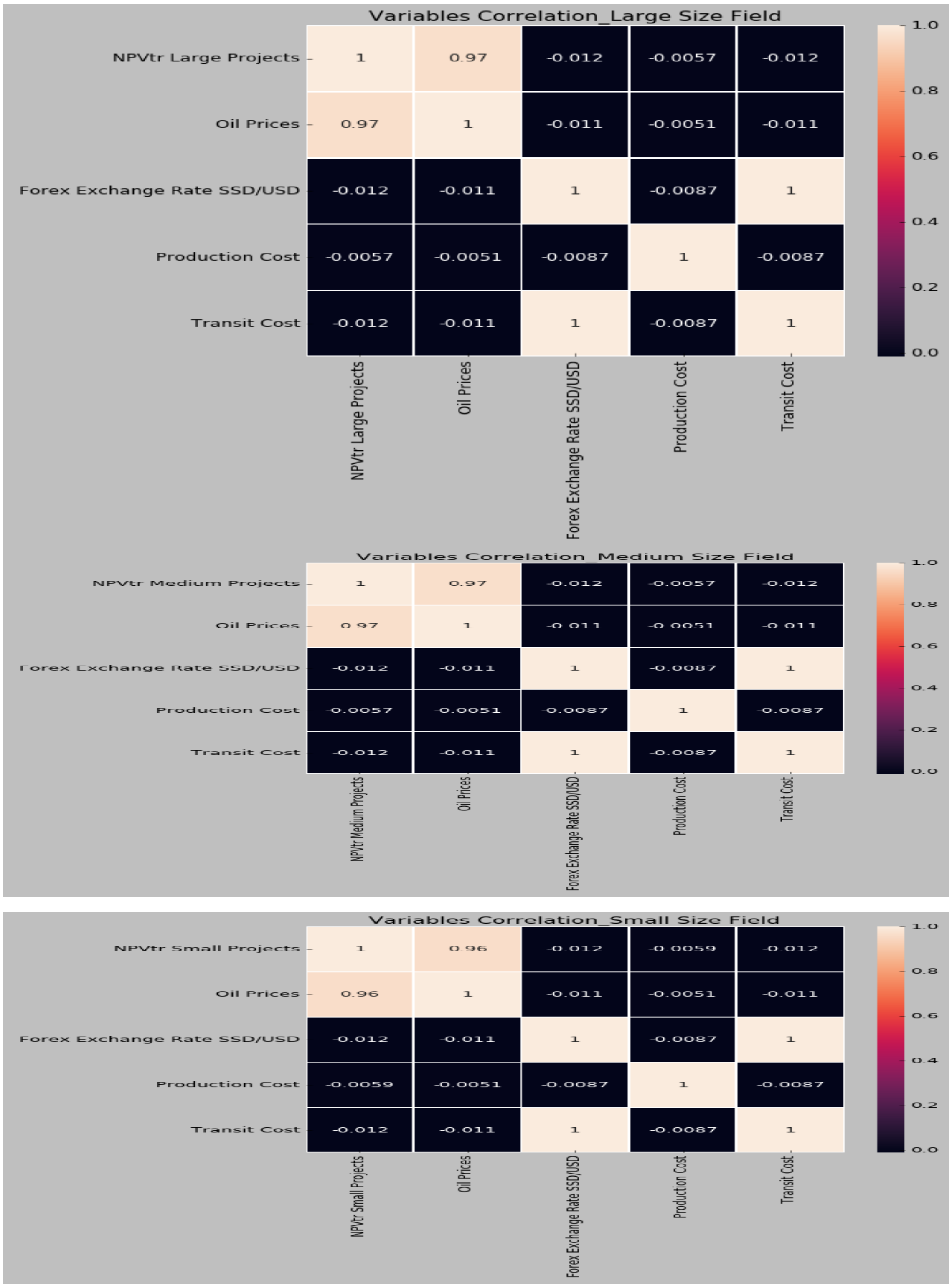
- Furthermore, the coefficients result shows that, oil prices variable has a weak and negative correlation with Forex exchange rates, production cost and transit cost at values of -0.011, -0.005, -0.011repectiveyly. this can be interpreted as follow, the more oil prices go up the more forex exchange rate value goes down which means that the local currency for the oil producing country gain momentum as the prices generate revenue through crude oil sales, this could happen specially when the exchange rate regime adopts a floating rate system, as far production cost is concern, the negative correlation reflects exogenous cost that is deducted from cash flow per barrel.

- Another coefficient that worth consideration is the forex exchange rates versus production cost and transit cost, the coefficients are -0.0087 and

+1 respectively, the values shows that forex exchange rates is weakly and negatively correlated to production cost, this result shows less significance, however the negative correlation draws the question whether the forex exchange rates should go down when production cost increase, the prior research suggest that the exchange rate is significantly and strangely correlated to commodities prices(Henriques & Sadorsky, 2011), but the contradiction of this result could be trace back to the assumption made by(Fan & Zhu, 2010b; Zhu et al., 2015) when they used CPI parameter as a proxy, this proxy variable has an impact on production cost results as in Table 4. due to high value of volatility generated from CPI data.

- The most important coefficient for this thesis is the transit cost vis-à-vis NPVtr and oil prices; it is the subject of this research, transit cost has a weak and negative correlation with NPVtr and oil prices at values of -0.011 and -0.0087.
- Some interesting observation this correlation is that, the three oil fields sizes generate the close correlation values, this happen due to the commonality in some input values particularly, CFs and PVs.

Figure 7: Variables Correlation



Source: analysis form Appendix 1

The conclusion in this correlations is that, the transit cost has a weak imact in this case given the parametrers in the simulations, when transit cost increase the NPVtr, Forex exchnage rates, production cost and oil prices are considred to be weakly and negativey correlated except for the case of forex exchange rates.

4.5.3. The impact of transit cost

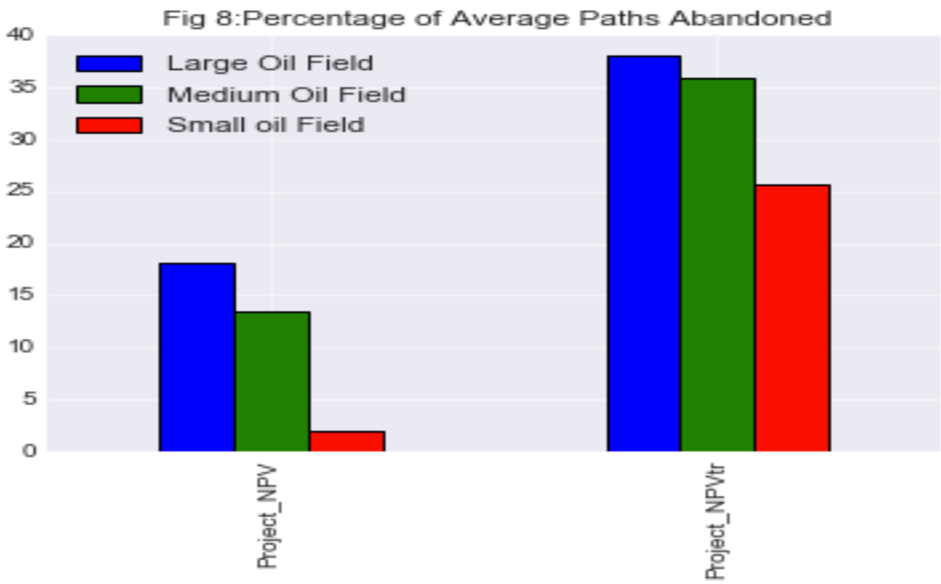
The data in table 5 is a result of NPVs rules application to cash flows , present values and initial investment for three types of oil field sizes. Figure 8 is a summary of analogy for Net Present Value (NPV) before the transit cost is included and NPVtr after the transit cost was added to the calculations. The result seeks to establish variables impact on net present values under transit cost regime and how it pose risks and hence jeapderize the investment

Table 5: Investment Projects Valuation Results

Projects NPV before transit cost	**Simulations**	**Large Oil Field**	**Medium Oil Field**	**Small Oil Field**
% of paths abandoned	1st	18.4%	14.06%	2.24%
	2nd	18.06%	13.45%	1.97%
	3rd	18.06	13.48%	1.95%
	4th	18.09	13.46	1.94%
	5th	18.0	13.468%	1.95%
Average Result NPV		**18.054%**	**13.46%**	**1.96%**
Projects NPVtr after transit cost				
% of paths abandoned	1st	38.78%	35.92%	26.48%
	2nd	37.99%	34.81%	25.36%
	3rd	37.98%	35.02.78%	25.38%
	4th	38.10%	34.64%	26%
	5th	38.0%	34.70%	25.86%
Average Result for NPVtr		38%	35.786%	25.59%

Source: Data analysis

Figure 8: NPVs Abandoned paths



Sources: Table 5 data Analysis

4.6. Multivariate Regression Analysis

This data is a result of NPVs, NPVtr calculations, the regression model is implemented to additional investigate the effect of Transit Cost on investment project decisions in a land locked country. the data in the table 6 is summarized using "dataframe.head()[3]" function to select few rows of 5000 variables population, the rest of the data can be found in the Appendix1. The regression has been applied to Large Oil Fields because the correlation value suggests that, the three sizes of oil fields share the same values, therefore, the sample of repressive and could be used to further the analysis

[3] This function is a global function in python program that give few numbers of rows as a summary for the data set

Table 6: Values for Large Oil Fields Project

S/No	NPVtr Large Projects in USD	Oil Prices	Forex Exchange Rate SSP/USD	Production Cost in USD	Transit Cost in SSP
0	852.5998097	7.7364039	31.08261214	221998581.8	295.2848154
1	15192.78474	44.1443162	35.44891692	471546073.3	336.7647107
2	8223.393051	38.19911249	55.67942006	529097725.6	528.9544906
3	-715.1904711	69.10519803	29.25144396	163882925.9	277.8887176
4	1299.885162	34.44138794	130.8037353	219731272.9	1242.635485
5	34.26336545	636.6382817	41.58706048	201133454.5	395.0770746
6	508.4936865	326.4626447	199.8169846	208723562.3	1898.261354
7	-959.9827187	60.22189145	31.28122884	524626631.2	297.171674
8	-983.6635447	90.17262248	45.64556709	75805067.87	433.6328874
9	14996.68747	4.939256369	70.40607653	324099641.9	668.857727
10	1008.438444	22.3591492	50.28813055	136300704.1	477.7372402
11	457.6349857	32.00958404	21.924714	64405305.44	208.284783
12	3954.098979	66.43679744	14.5062749	117008447.4	137.8096115
13	2194.255921	44.09731308	77.93410255	233187014.4	740.3739742
14	-1057.030152	11.09977939	22.03638316	196043921.4	209.3456401
15	916.3855819	180.9089655	75.52124302	633350320.9	717.4518087
16	472.8230592	5.190656826	42.50449817	114930700.8	403.7927326
17	31063.92162	53.12086498	15.09951378	261222955.4	143.4453809
18	1653.196994	9.848641504	57.08902969	664585754.3	542.3457821
19	-306.4586371	20.66308549	364.8116883	226839615.4	3465.711039
20	-822.203416	66.18425215	39.92155723	134202810	379.2547937
::	:::::::::::::::::::::	:::::::::::::::::::::	:::::::::::::::::::::	:::::::::::::::::::::	:::::::::::::::::::::
4999	8991.707152	241.6584116	16.29729832	195502253.2	154.824334

Source: Analysis form Appendix1

4.6.1. Linear Regression Results

The regression model is built by deploying SciPy library and sklearn module from python. It is a rich library that utilize part of variables values to train the model before the implementation. About Table 4, the independent variable is net present value at transit cost while depended variables are oil prices, forex exchange rates, production cost and transit cost. It can be represented by the following formula:

$$\boldsymbol{NPVtr = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4} \qquad (\boldsymbol{a})$$

In this equation, $\beta_0, \beta_2, \beta_3, \beta_4$ represent the effect of each independent variables on NPVtr and X_1, X_2, X_3, X_4 are the depend variables namely; oil prices, exchange rates, production cost and transit cost. After carrying out the regression analysis base on code lines in appendix 1, the result is as follows

Table 7: Regression Analysis Results

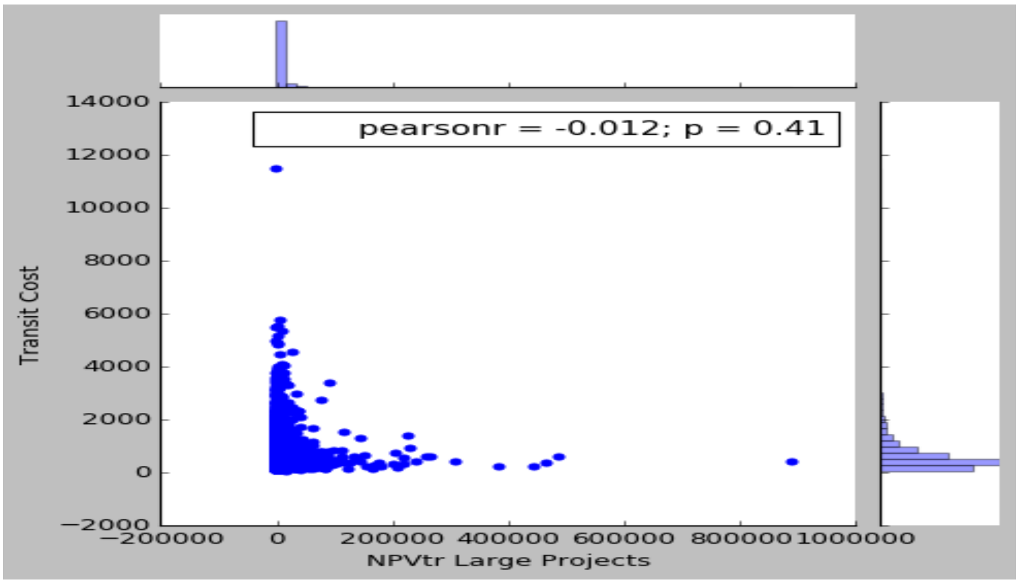
Variables	Coefficient Values
Oil Prices	21.16361236
Forex Exchange Rate	-0.006475804
Production Cost	-3.93171E-13
Transit Cost	-0.061522558
Intercept	231.91

Source: Appendix 2: Data Analysis

$$\boldsymbol{NPVtr = 231.91 + 21.16X_1 - 0.01X_2 - 0.00X_3 - 0.1X_4} \ (\boldsymbol{b})$$

From equation (b) it can be observed that, transit cost has a negative effect on net present value as confirm as well by the correlation in figure 7, however, this effect seems to be very small comparing to other variables like oil prices. The model suggest that production cost has not impact on net present value, the reason is that, there is a strong multicollinearity of variables as shown in correlation results, specially between forex exchange rate and production cost. However, Figure8A provides more insight on how production cost reacts to Net Present Values (NPVtr) after transit cost recognition in calculations

Figure 8A: Production Cost vs NPVtr



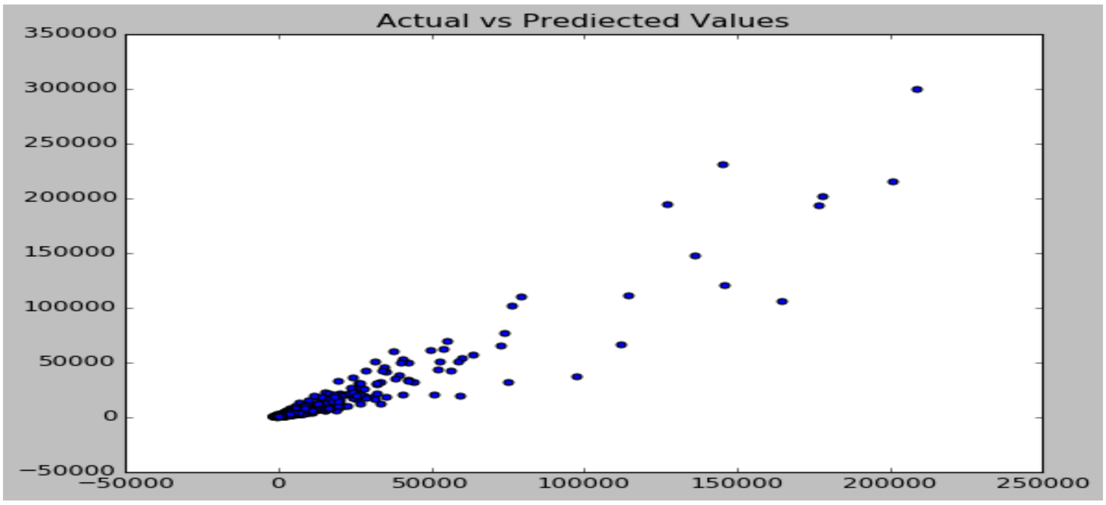
Source: appendix 1

The chart tells that the more transit cost increases the more Net Present Values decreases as exhibited in axis x.

4.6.2. Model Evaluation

The following Figure 8 represents the relation between the actual values for the valuables and precited values form model in equation (b), to some extend this chart describe the accuracy of the model but that is not adequate. There has a true measurement of regression model performance like "Mean Absolute Error," "Mean Square Error" and "Root Mean Squared Error," the following values were obtained, MAE value is 2085.906, MSE value is 3227225.50 and RMSE is 5681.04, these values measure the errors in regression models, however, it works best when considering more than one model for comparison.

Figure 8B: Model Evaluation



Source: Appendix 1, Data Analysis

Furthermore, R squared value is very critical to check if the model represent the population of the data used to build the regression model, in reference to Appendix1 the R-squared value is about 0.88, this shows to some extend that the model represent 88% of the population of data, this imply that 88% values for NPVtr can be predicted and calculated using model in equation (b).

This situation advises that the investing companies could investment in Small oil field size than medium and large fields specifically in this case where average spot oil price is $40.76 per barrel[4], production cost is $17.62, forex exchange rate is 46.81 SSP/USD and initial project cost for the three oil fields sizes are in Table 2B in Appendix1.

In Summary, the methods deployed, calculations and procedures followed in chapter 3, do follow the paths of previous research work carried out, however, this thesis focus more on specific case that takes landlocked country as a subject for the study. The exploratory data analysis for oil and gas and investment projects evaluation, confirm that transit cost has a "negative impact" on Net Present Value on oil and gas investment project. However, oil and gas investment project sizes

[4] The average spot price is derived from the data set for historical oil prices for year 2016, all values are Appendix 1

carry different level of risks associated with abandoning NPV paths as table 5 shows, this result addresses the question 2 of my research, the project could perform under low NPVtr hence the forex exchange reserve is affected indirectly as shown in figure 7 where oil prices and production cost negatively correlated to forex exchange rate.

4.7. Sensitivity Analysis

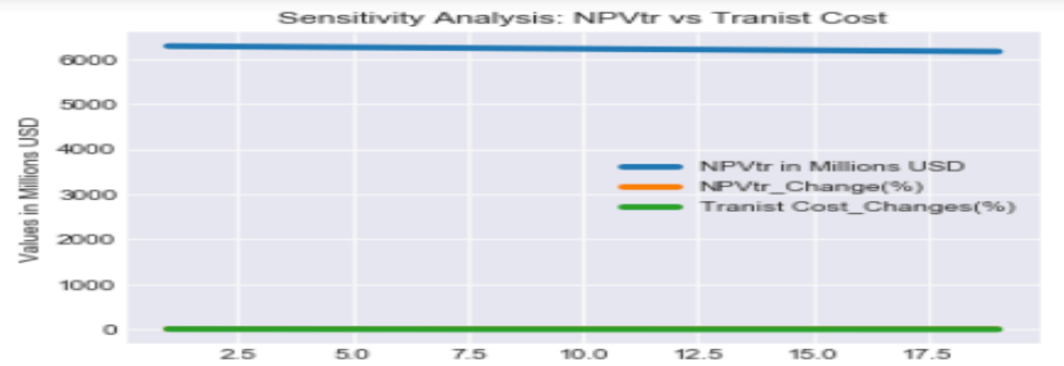
This sensitivity analysis is trying to analyze the impact of changes of the three factors, Oil Prices, Forex Exchange Rates and Transit Cost on the Net Present Value (NPVtr). The following Figures 9,10,11 have been generated from sensitivity analyses table as in appendix1 in item No.6.5.3.

Figure 9 explains how increment in transit cost decreases Net Present Value for the investment project. It can be noticed that the change negatively makes NPVtr decremental with a very small values in percentages; this to say that, when transit cost change with 5% the NVPtr change by -0.11%.

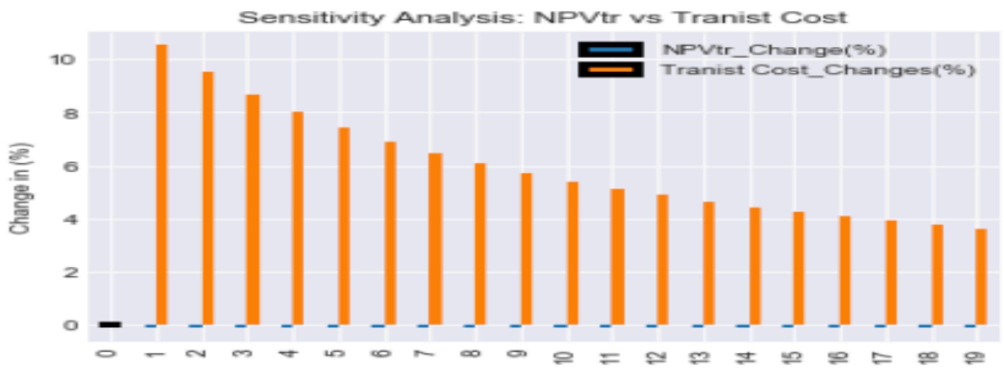
Figure 10 describes the impact of forex exchange rates risk on oil and gas projects, the charts inform that, six percent 6% in average variation in forex exchange rates has a negative impact on NPVtr with change equal to -0.00113% in tis values in millions USD.

Moreover, in Figure 11, the impact of oil prices on investment project is established in the charts; when oil prices change by decreasing with -0.55%, the Net Present Values goes down by -0.0011%.

Table 9: Impact of Transit Cost on NPVtr



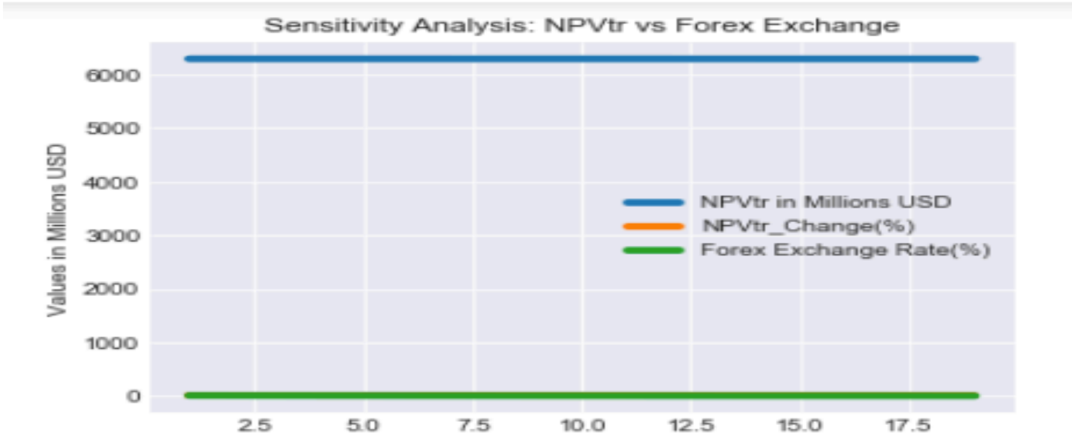
<matplotlib.figure.Figure at 0x11b6e9da0>



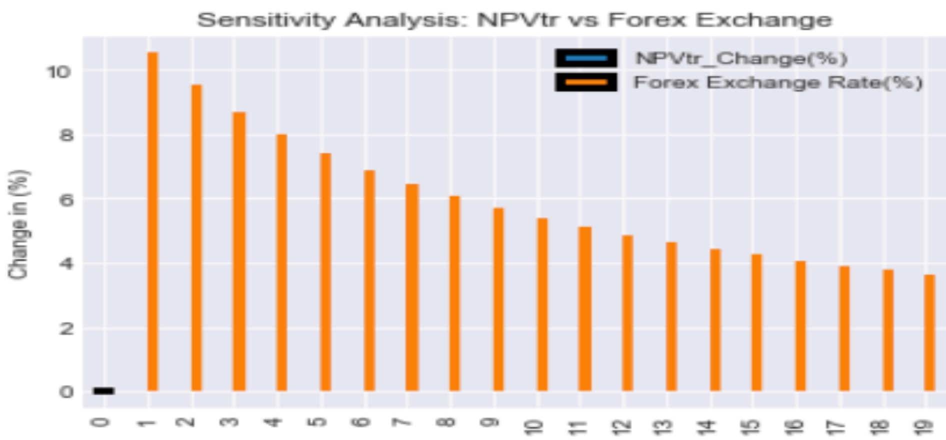
	Sensitivity Result:NPVtr-Tranist Cost
NPVtr in Millions USD	6226.093720
NPVtr_Change(%)	-0.108149
Tranist Cost_Changes(%)	5.971157

Source: Appendix 1

Table 10: Impact of Forex Exchange on NPVtr



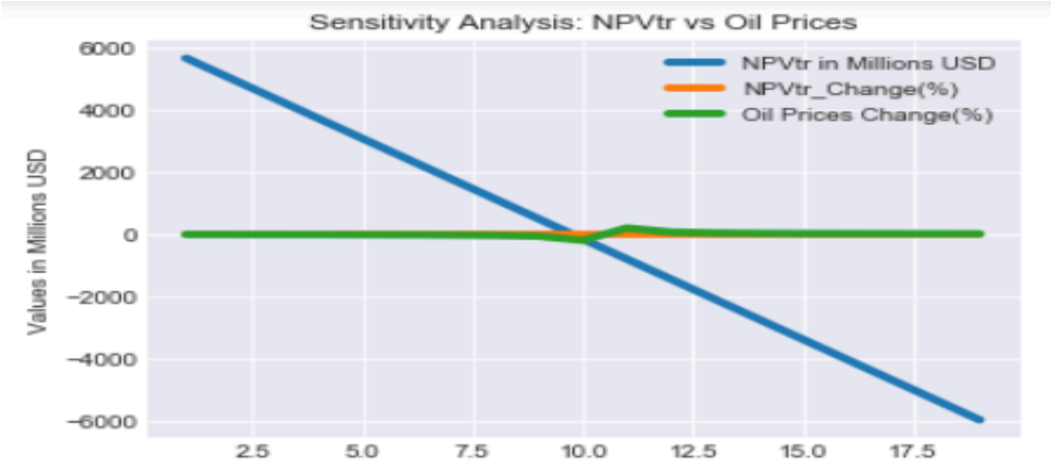
<matplotlib.figure.Figure at 0x11b68d198>



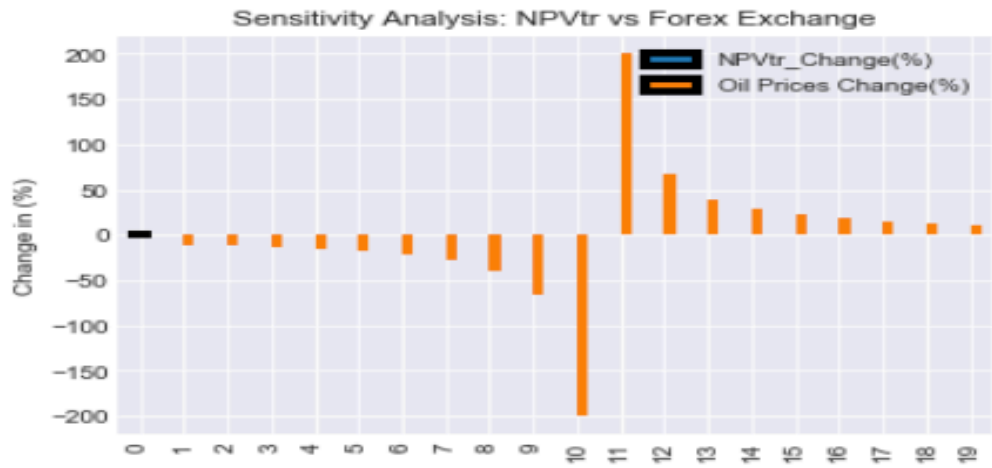
	Sensitivity Result:NPVtr-Forex Exchange
NPVtr in Millions USD	6289.419840
NPVtr_Change(%)	-0.001128
Forex Exchange Rate(%)	5.971157

Source: Appendix1

Table 11: Impact of Oil Price on NPVtr



<matplotlib.figure.Figure at 0x11b5d7c88>



	Sensitivity Result:NPVtr-Oil Prices
NPVtr in Millions USD	167.236120
NPVtr_Change(%)	-0.001128
Oil Prices Change(%)	-0.554017

Source: Appendix1

In summary, the sensitivity analysis, shows the influences made by the independent variables, transit cost, forex exchanges and oil prices. The Production cost has not been included in the sensitivity analysis because it has no statistics significances according to regression analysis model in equation (b). It is obvious from the charts that, the three variables affect Net Present Values for oil and gas investment projects. However, it is concludable that the oil prices have more influences on NPVtr values followed by transit cost and forex exchange rates which has less significant impact on oil and gas investment projects.

Chapter_5: Conclusions and Further Research

5. Conclusion Notes

5.1. Introduction

As decisions on project related to exploitation of mineral resources becomes complex, oil and gas investment projects decision is more complicated due to the number of Risks around the payoff for those investment projects. Many Risks have been considered and modeled in the previous research work, however this thesis argues that geography of oil producing country could make investment endeavor more uncertain. A computer aided simulation with Python programing language was used to build Monte Carlo simulations and multivariate linear regression to model the risks. I have taken South Sudan as case study for this research because it meets the criteria of landlocked country in addition to the oil reserves it holds, but importantly it is subjected to high transit cost by the transit country, the transit country here refers to the Republic of Sudan which is the only option for South Sudan to export its crude oil via trans-border pipelines. The research is trying to investigate these three questions *(i)*what is the impact of transit cost on different sizes of oil and gas projects given specific parameters represented by oil prices, exchange rate, production cost and transit cost?

Furthermore, the analysis was applied to standards three different sizes of oil fields based on the previous research to establish an analogy of transit cost impact on oil and gas net present value, in addition to that of five seeds of 5000 simulations have been run for each seed to ensure accuracy in the results. Data and related information were sourced from OPEC, South Sudan, World Bank repositories, Central Bank of South Sudan and IMF data base.

5.2. Research Results

Oil industry is a business that is so sensitive to fluctuating of oil prices, business environment of the producing country and the forex exchange rates, this thesis take furthermore by considering landlockedness as factor that can make decision more complex when there is planning for new oil and gas investment projects.

The results show that, transit cost could greatly affect decision process in landlocked country like South Sudan, when oil prices go lower, forex exchanges rates increase, and when production cost increases, the Large oil fields carry more risks around 38%, more than Medium fields and Small fields which hold risks of paths abandoned at 35.79% and 25.59% respectively. This specific result is in line with quest for answering question1 of this thesis, the question 1looks for answering by finding out to what extend the risk could be measured and quantified across the three sizes of investment projects. Although this result could not be generalized but the applicability of this method is handy for any landlocked country.

Moreover, the research has an important finding that, the landlocked countries carry more risks as per figure 8 shows, where NPV value before the transit cost tend be 18.059%,13.46% and 1.96% for the three sizes of oil fields large, medium and small respectively, this confirm that there is a risk of abandoning some project paths for non-landlocked countries more than oil producing landlocked countries. However, it indicates that, the transit cost could undermine investment decisions in landlocked countries than non-landlocked countries.

Since the purpose of exploiting of oil and gas resources is to create economic rent for hosting country's government, it is worth noting that the ultimate pursue is to maximize the economic, social benefits for the population by providing development projects that serve national of objectives. The implication on country's fiscal regime is paramount because the diminishing revenues due to country's geography is significant as far resources benefits maximization is concern, thus putting close attention and establishment of adequate evaluation procedures that include transit cost into evaluation in conjunction with other risk factors like oil prices, exchange rates is very critical as this model is concern.

5.2.1. Implications on Managerial Practice

The investing companies e.g. Foreign Oil Companies tend to assess risks and Risks before taking major investment decision on overseas, this research provides a well-researched question that have managerial implications in term of action related findings. The correlations matrix suggests the that, transit cost has a negative correlation to oil prices, production cost, net present value and positive correlation with forex exchange rates, it is so complex to find the trade off point as to what extend the risks configuration could be managed because it beyond the methods used in the research, but it is an interesting finding that management should peruse to develop an insight on how to treat this kind of risks arrangement

First, it is apparent that the risk could not only be assessed based on oil prices, however, there are other variables that may make decision on investment project more uncertain, therefore, exchange rates, production cost and Risks around initial capital were considered. This calls for proper optimization process for the companies who have already involved in investment initiation.

Secondly, transit cost turns out to be a significant factor that could compromise cash flows and net present values of investment projects, therefore, emphasizing on evaluation of this factor could help shed more understanding at corporate level when taking major decision on investment capital allocation.

5.2.2. Recommendations & Further Research

This thesis provides a thread of literature that capture the behavior of NPVtr under transit cost for oil and gas projects. The results, methods used in data collection, and analysis exhibits some degree of consistence throughout this research, however, there are some limitation that may probably weaken the judgement as far as investment decision is concern.

First, the analysis assumes continuity of production process without depletion, which is contrary to industrial practice, for that reason it paramount that, the rate of natural resources depletion be included in the model to provide more accurate result for project abandonment risk.

Secondly, in this research work, the comparison was done among project sizes, for better result on the impact for transit cost on investment net present value, further research can be directed towards the areas of assessing the impact of transit cost on many oil and gas fiscal regime contracts because this thesis uses production sharing contracts.

Thirdly, since this result could not be generalized to all landlocked countries, the next avenue of research needs to consider comparing studies among landlocked countries to improve the analysis. But most importantly the next research can consider doing analysis for both foreign oil companies(FOC) and National Oil Companies in other hand.

In Summary, this thesis tries to figure out to what extend the transit cost could affect decision process, the research looks at monte Carlo simulation as a robust tool to explore full probabilities of 500 paths that may affect net present values for different sizes oil and gas projects. The research provides some literature insights to handle multi Risks amid decision process practice in present of conflicting and complex factors, the model provided here made it possible to expand the number of variables. Recommendation for further research to enrich decision process has been provided in the conclusion notes as well.

Appendices

Appendex_1: Calculations

Item	Descriptions
Click here for the calculations.	This file contains some of the calculations used in this research

Appendix_2: List of Tables

Table	***Description***
Table1	*Data Sourcing*
Table 2A	*Fields sizes data*
Table 3	*Independent Variables*
Table 4	*Descriptive statistics*
Table 5	*Investment Projects Valuation Results*
Table 6	*Value for Large Size Oil Field*
Table7	*Regression Analysis Results*
Figure 8A	*Production cost vs Net Present Value Chart*
Figure 8B	*Model Evaluation*
Figure 9	*Impact of Transit Cost on NPVtr*
Figure 10	*Impact of Forex Exchange on NPVtr*
Figure 11	*Impact of Oil Price on NPVtr*

Appendix_3: Model Parameters

Parameter	Value	Description
Oil Prices (Pr_{Cr})	$41.67	This average oil cost was derived from time series data for OPEC basket of 2016
Annualized oil prices return (μ_{Pr})	1.35	Set by this research
Oil prices annual volatility (σ_{Pr})	0.50	Set by this research
Annualized Prices Risk premium (α_{Pr})	1.34	see Appendix1
Crude oil cost per barrel (C_{Cr})	$17.63	The original cost for 2014 is $10.20 but the inflation factor of 20% for 2016 was included to calculate the production for 2016(Kate Ashcroft, 2018), appendix1
Production cost return (μ_c)	0.63	Set by this study
Production cost volatility (α_{Pr})	2.31	Set by this study
Annualized Prices Risk premium (α_C)		See appendix 1

Forex Exchange rates (SSD/USD, Ex)	46.81	From Bank of South Sudan data
Ex annualized return (μ_{Ex})	4.15	See Appendix 1
Ex volatility (α_{Ex})	0.23	See Appendix 1, Table 2B
Investment cost initial cost (L, M, S), I_{ti}	\$77m, \$63m, \$49m	See Appendix 1
Total Investment cost initial cost (L, M, S), $K_{inv}(t_i)$,	\$308m, \$16m, \$49m	See Appendix 1
Project Investment cost risk (β)	0.5	Derived from (Dixit & Pindyck, 1994; Zhu et al., 2015)
Corporate Income Tax ($Tax_{inco.}$)	15%	E&Y, Ministry of Finance, Juba
Government Share (g_{govt}) %	8%	From EPSA[5] document
Oil Cost (cl_{oil})	45%	From EPSA[6] document
Transit cost per barrel	\$9.5	Sudan & South Sudan Oil Agreement, this value exclude other financial obligations
Risk free rate (r)	13.3%	Obtained from world bank (The World Bank Group, 2015)
Number of Simulation (Paths)	5000	From previous studies see appendix 1
Project Life Cycle	25 years	From South Sudan Oil Project Conceptual design
Time steps	1 year	Set by this study

[5] EPSA stand for Exploration and Production Agreement, it is another name for Production Sharing Agreement contract

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