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Financial decision making about found oil and gas in Ghana : real options vs. traditional methods

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Financial decision making about found oil and gas in Ghana: Real Options vs. Traditional Methods

By

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A Thesis

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN APPLIED NATURAL RESOURCE ECONOMICS

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This thesis, “Financial decision making about found oil and gas in Ghana: Real Options vs. Traditional Methods” is hereby approved in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN APPLIED NATURAL RESOURCE ECONOMICS.

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ABSTRACT

This research is a study of the use of capital budgeting methods for investment decisions. It uses both the traditional methods and the newly introduced approach called the real options analysis to make a decision. The research elucidates how capital budgeting can be done when analysts encounter projects with high uncertainty and are capital intensive, for example oil and gas production. It then uses the oil and gas find in Ghana as a case study to support its argument.

For a clear understanding a thorough literature review was done, which highlights the advantages and disadvantages of both methods.

The revenue that the project will generate and the costs of production were obtained from the predictions by analysts from GNPC and compared to others experts' opinion. It then applied both the traditional and real option valuation on the oil and gas find in Ghana to determine the project's feasibility.

Although, there are some short falls in real option analysis that are presented in this research, it is still helpful in valuing projects that are capital intensive with high volatility due to the strategic flexibility management possess in their decision making. It also suggests that traditional methods of evaluation should still be maintained and be used to value projects that have no options or those with options yet the options do not have significant impact on the project.

The research points out the economic ripples the production of oil and gas will have on Ghana's economy should the project be undertaken. These ripples include economic

growth, massive job creation and reduction of the balance of trade deficit for the country. The long run effect is an eventually improvement of life of the citizens. It is also belief that the production of gas specifically can be used to generate electricity in Ghana which would enable the country to have a more stable and reliable power source necessary to attract more foreign direct investment.

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It will be very unpardonable and highly ungrateful to forget my family. I need to thank my family, Robert and Mercy, my parents, Esther and Elizabeth my sisters for the gallant support they have rendered to me.

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Chapter One

1.0 Introduction

It is imperative that management become very circumspect about allocating limited resources among competing opportunities. The critical decision of allocating resources for a project is known as capital budgeting. The ability to make such a critical capital allocation decision requires a proper estimate of the worth of each opportunity concerning the projects which is a function of size, timing and predictability of future cash flows.

Making a decision to invest in exploring and/ or exploiting a potential oil and gas field is a highly risky but very important one, since energy is one of the driving forces of any economy. The oil and gas industry is very profitable but there are associated problems because oil and gas exploration and production involve significant amounts of uncertainty. When drilling for oil and gas, the reservoir and fluidic properties, trap size and the geometry, porosity, seal containment of the oil and gas in place, expulsion force, and losses due to migration development costs are not known. Should these uncertainties stop investors from financing oil and gas exploration and exploitation and choose other ventures? Certainly not, as the quest and demand for oil and gas continue to rise due to the needs of growing population and technology.

The world economy has undergone a dramatic change through the help of information technology. This brings the world to a new division of labor and transformation of work that creates new opportunities for businesses. Nonetheless, information technology with all it offers does not transport goods. Transportation is still an important issue for wealth creation and requires the need for more and more oil and gas production. How then should a potential investor consider a project worthy of being undertaking in the oil and gas industry? These necessary but risky ventures can be done through a careful valuation technique.

There are several traditional methods used by analysts for evaluating a project's viability. These include the net present value, internal rate of return, payback method and others. However, none of these investment assessment tools for capital budgeting takes into consideration the uncertainty of variables that may occur in the future. While, the traditional methods of analyzing projects are widely accepted, they neglect management's ability and flexibility to respond to uncertainties that are likely to affect their projects.

The traditional methods typically assume a single line of development for a project and simply incorporate the probability of failure into the overall expected value for the project. The probability of failure is carried as a discount rate that in itself is a very hard value to assign. These and many other reasons account for the flaws in the traditional methods for analyzing a project and therefore the need for a more robust approach.

The most recent technique which is considered to be more robust for making capital budgeting decision is real option analysis. This method of valuation is a useful tool for making decisions for capital intensive ventures which are very risky. It is considered to be very robust because it takes into account uncertainty and the flexibility that management can exercise. The advent of real option analysis has been hailed by many analysts because it provides an explicit method of incorporating option values into the analysis for any investment which traditional methods lacked in the past. Also, this technique shows a project as a process that management can continually modify as new information become available. It can be said that real option analysis does not force projects to be automatically economic profitable but rather anticipate the uncertainties and provide options and solutions for them.

This research uses both the traditional methods and real options analysis to evaluate a project that is potentially risky and also involves a huge capital investment. The example is a potential oil and gas field in Ghana.

The research suggests that the potential oil and gas field found in Ghana should be valued by real option analysis because this technique does not automatically require the country's decision to develop the oil and gas now, but rather helps the country to look into the future and make provisions for an eventual development.

In Ghana, the government controls most of the resources and reserves, including all minerals and oil or gas, considered as common property for the citizens. There has not been any major upheaval or insurgency by any group of people in the country over government control of resources, but there have been numerous minor conflicts between local communities and firms where minerals such as gold, diamond, bauxite and manganese are mined.

These conflicts happen because the communities believe that they have a justifiable right to seek a fair share of the proceeds from the companies exploiting the minerals found on their lands. To ameliorate these minor confrontations between the local communities and firms so as to reduce the political risk, critical decisions must be made concerning all resources and reserves especially the potential oil and gas fields in Ghana. This can be done by introducing private ownership principles.

Most people in Africa are not familiar with individual ownership of properties; they are used to communal system of ownership which says all things belonging to the society. Therefore, deciding to implement a property owning democracy will cause resistance. It is essential in this modern age to have private ownership principles gradually introduced to help solve many minor conflicts and those that are likely to ensue especially when oil and gas are found. When citizens are well behaved and understand the principles of private ownership, political risk of firms will be reduced, which makes the project more viable.

The objective of this research will be achieved through extensive literature review and data analysis using computer software. The research is focused on developing a clear understanding of real option analysis, its shortfalls, and the solutions it reaches in comparison to traditional methods. Therefore the research will cover the theoretical advantages and disadvantages of real options analysis by juxtaposing it with an existing situation.

Chapter Two

2.0 Purpose of Research

In 2000, Bain & Co. conducted a survey across more than 30 industries about the use of 25 management decision tools. The outcome of the survey showed the unpopularity of real option analysis: just 9 percent use real options for their project evaluations. Unfortunately, real options analysis usage was the penultimate on the list. The survey revealed that an average of 32 percent of 451 senior management executives had stopped using real options. Furthermore, Teach reports another survey released by 205 Fortune 1000 CFO magazine in 2002 that was done by Professor Patricia A. Ryan of Colorado State University. Her survey showed that real options analysis is trailing behind many capital budgeting tools. The survey showed that 11.4 % used real options, 66.8 % used scenario analysis, 85.1 % used sensitivity analysis and 96% used NPV (Teach, July 2003).

Notwithstanding these statistics, Professor Alexander Triantis of the University of Maryland's Robert H. Smith School of Business is optimistic that the real options will soon be accepted and juxtaposed his belief with the example of NPV, which took more than10 years to be accepted by firms, analysts and businessmen (Teach, 2003). Now, NPV is widely used by all as illustrated by the Professor Patricia's survey. Similarly, it has also been predicted by Tom Copeland and Vladimir Antikarov that real options analysis is poised to conquer the corporate world if not in the short term, it will definitely come to reality in the long term (Antikarov & Copeland, 2003). Will their predictions come to reality when most people are very reluctant to change the status quo from the traditional approach to the new method –real options analysis?

This paper explains both traditional methods and real option analysis, and it shows how they can be used to value investment, especially those that involve huge capital with high uncertainty. The paper uses a project which is being evaluated by the Ghana National Petroleum Corporation (GNPC) and its partners. The point of this research is to illustrate which technique is the most effective when evaluating a project that is both very risky and capital intensive. Both the traditional methods and real options analysis are used to evaluate the project. This is done to verify the following:

- Will traditional methods particular NPV and decision tree analysis give a better evaluation than the real option analysis?
- What are the factors that motivate analysts to use traditional methods or real options?
- What are the shortfalls of both the traditional approach and real option analysis?
- Which of the methods is the best criterion to use for capital budgeting decision and under what conditions?

2.1 Situation in Ghana

2.1.1 Why is this a critical decision for Ghana?

Although Ghana is well endowed with many natural resources such as gold, diamond, timber, cocoa and coffee, the country is heavily dependent on the international community for financial and technical assistance. This is because the domestic economy predominantly revolves around subsistence agriculture, which accounts for about 35 % of the Gross Domestic Product (GDP).

Ghana is not an industrialized country. It imports numerous commodities and exports a few such as agricultural produce and metal ores. Consequently its budget runs at a deficit in the balance of trade account which tends to weaken its currency. For example Ghana spent about 2.1 billion dollars for importing petroleum and its products alone in 2007, and it is expected to increase to 2.5 billion dollars by the end of 2008 (Lewis, 2008).

The country still depends on the mercy of the weather to power its few industries through its dependence on generating electricity by hydroelectric power. This system of generating electricity has been impacted by low rainfall reducing the water levels needed to turn the turbines of the hydropower plant. The river Volta which is the main source of water that turns the turbines to power the hydro-plant for Ghana is also being used by Burkina Faso to generate their electricity therefore increasing Ghana's woes.

Unemployment plagues the country because there are not enough industries. It is important that government find a better means of creating jobs, especially for the able working force, by positioning the country to attract more investors through proper policies in terms of energy stabilization and reliability. Quite recently, the crime rate has dramatically increased in the country. Of course there is no way one could rule out crime in any society, but when there is no employment, crime such as thievery, prostitution, drug trafficking, and other illegal activities, will rise. More employment opportunities will tend to reduce this problem.

Will the good news of the country's discovery of oil and gas help ameliorate Ghana's creeping economy and be able to restrain the rising social problems? It behooves the country to make a critical decision about the production of oil and gas in order not to waste the very limited resources the country has but to create more wealth for the citizens.

The oil and gas found in many countries, especially in Africa, have become more of a curse than a blessing, due to how the resources are allocated within the community where production takes place. It is essential that the proceeds gained from the eventual production of oil and gas in Ghana be allocated properly so as not to create unnecessary insurgencies and mayhem in the country.

2.1.2 History of Exploration and Production

Ghana has five sedimentary basins that are considered to have prospects for oil and gas: Tano Basin, Saltpond Basin, Accra/Keta Basin, Voltaian Basin and Cape Three Points Basin as shown Figure 1. Petroleum exploration began as early as 1896 in Ghana where wells were drilled in and around Half-Assini in the western part of the country. This yielded a positive result as oil seeps were found at the onshore of the Tano basin and exploration work has continue unabated until now. So far about 89 oil wells have been drilled throughout the country's potential oil and gas regions and large discoveries have been made. About 75 % of 50 exploratory wells drilled have had varying degrees of hydrocarbon signifying a good chance for a commercial discovery.

In 1970 the exploration for oil and gas intensified and was extended to the offshore of the country with moderate success. For example Philips Oil Company made some discoveries in the South and North Tano field in 1978 and 1980 respectively, but they were not commercially viable. For this reason the company abolished its plans for further exploration in 1982. This prompted the government of Ghana to establish the Ghana National Petroleum Corporation (GNPC) in the following year (1983). From the time that GNPC was established until today, it has done tremendously well and over 30,000km of 2-D and more than 5000 km^2 of 3-D seismic data have been acquired as shown in Figure 2.

Figure 1 is from the website of the Ghana National Petroleum Corporation (GNPC). Permission letter can be found in appendix E.

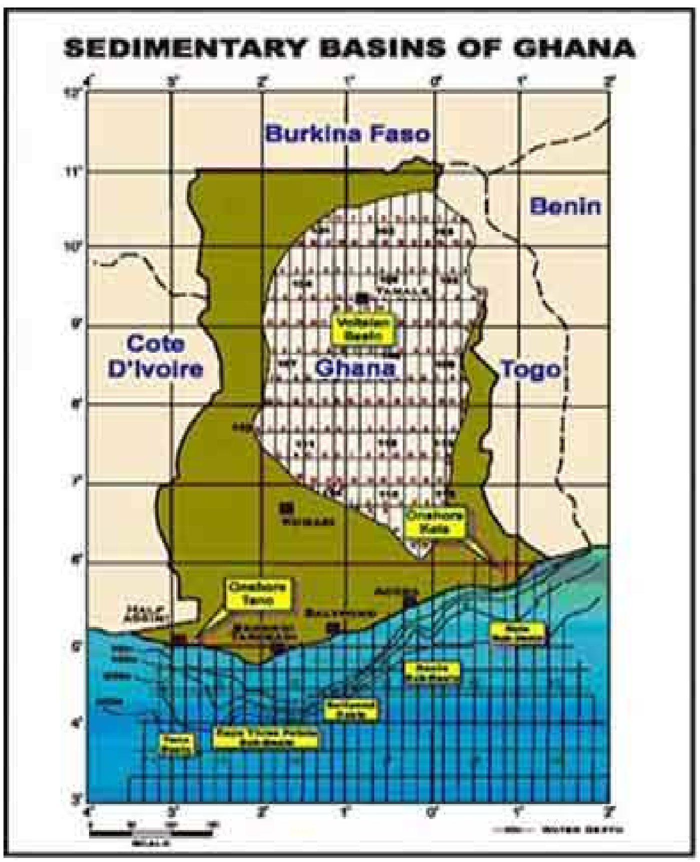

Figure 1. Ghana's Sedimentary Basins Map

Source: Ghana National Petroleum Corporation www.gnpcghana.com

Figure 2 is from the website of the Ghana National Petroleum Corporation (GNPC). Permission letter can be found in appendix E.

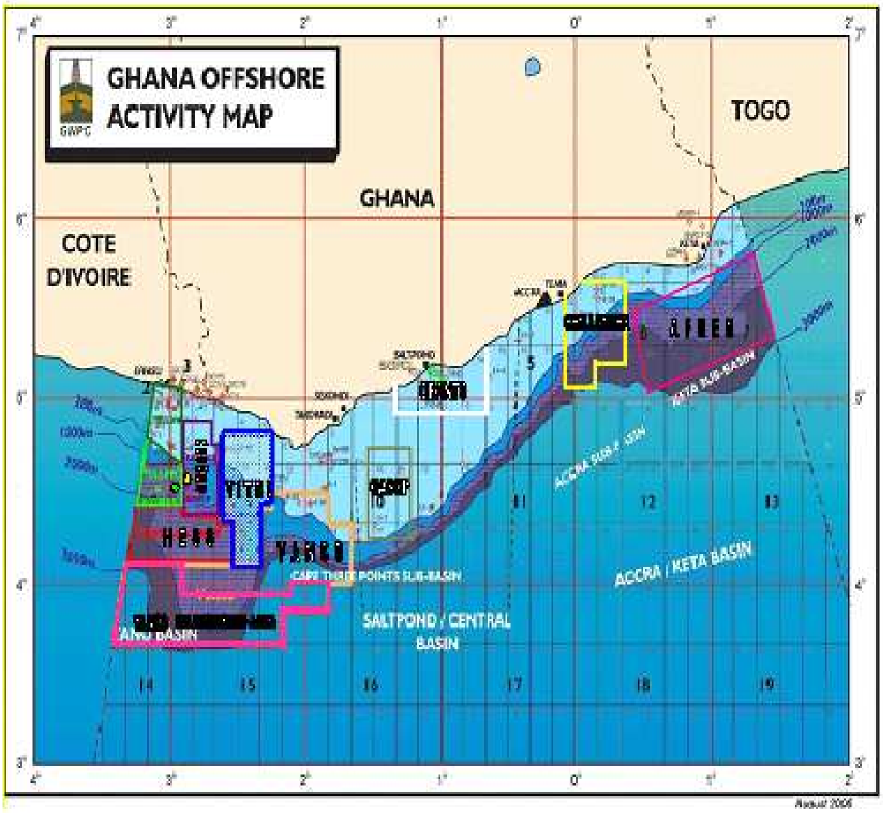

Figure 2. Ghana’s Offshore Activity Map

Source: Ghana National Petroleum Corporation www.gnpcghana.com

The GNPC has worked tirelessly with other firms to create some oil and gas production in the Saltpond oil field with a production platform called “Mr. Louie” which is still in place. The agreement between GNPC and some other firms resulted in the formation of Saltpond Producing Company Ltd (SOPCL) which is currently in operation. It is estimated that about 3.47 MMbo has been produced and 14 Bcf of gas was flared between 1978 and 1985 from this oil field. In an attempt to salvage the country’s power generation, the GNPC is negotiating diligently with a number of oil companies to make use of the otherwise wasted gas from this oil field for energy production.

There has been a dramatic increase in activities of oil exploration and production by GNPC. The GNPC has stated that in 2007 and beyond much emphasis will be placed on conducting appraisal well drilling programs. This will eventually lead to the development of the South, North and West Tano oil and gas fields to meet the increasing demand for oil and gas in Ghana and the world as a whole. The main objective of GNPC is to increase their petroleum production as well as intensifying its exploration through the drilling of many wells to find more reserves. Again, GNPC has plans to undertake reconnaissance exploration work through aeromagnetic and gravity surveys and their interpretations, as well as satellite imagery interpretation in the Voltaian Basin.

The GNPC on behalf of the country is making efforts to position the country to join the ranks of the fastest growing oil and gas producing countries within the Gulf of Guinea. The Gulf of Guinea is one of the richest hydrocarbon basins in the world. In this regard the GNPC has agreement with the firms listed in Table 1 that are currently operating in some of the oil and gas potential areas in the country for more exploratory work.

Table 1. Exploratory Firms Operating in Ghana

Company	Area of Operation	Beginning of Operation
Vanco Ghana Ltd.	DeepWater Cape Three Points	August 2002
Kosmos Energy Gh. HC Anadarko Petroleum Energy Tullow Gh. Ltd.	West Cape Three Points	July 2004
Saltpond Offshore Prod. Company	Shallow water, Tano Basin	July 2006
Vitol Upstream Gh. Ltd	Deepwater Tano Basin	March 2006
Amerada Hess Gh. Ltd	DeepWater Tano CPT	July 2006
Devon Energy Gh. Ltd	Offshore Keta Basin	July 2006
Gasop oil Gh. Ltd	Offshore Saltpond Basin	July 2006
Tullow Gh. Ltd Sabre oil & Gas Ltd.	Shallow Water, Tano Basin	July 2006

Source: Ghana National Petroleum Corporation www.gnpcghana.com

2.1.3 Legislation about Petroleum Exploration and Production

Ghana's oil and gas finding in large quantities that is likely to be produced commercially has become an issue of public interest and discussion. The current president of Ghana, His Excellency John Agyekum Kuffour, made a statement concerning this issue of Ghana's likelihood of producing oil and gas on a large scale or in a better sense commercially; he said that "our oil find must be appreciated as a national asset whose management must be above sectional or political interest"(Ghanaweb, February 26, 2008). Other public opinion is that everyone must accept that all revenue from oil and gas development belong to the people of Ghana rather than the politicians or business men. Others also think that the domestic price of oil and gas should be cheaper compared to elsewhere if any company should undertake this oil and gas production in Ghana.

Undeniably, the president's assertion is a valid and prudent idea, but other opinions have some truth as well. Thus, it is expected that the price of oil and gas will be cheaper since transportation cost will be less yet the cost of the oil and gas will not be as low as the citizens expect. For example, this is the same way some people in Nigeria continue to think. This way of thinking has always created unnecessary pressure on the oil companies and the government in Nigeria. In 1999, protests at Odi in the Niger Delta of Nigeria exploded and twelve policemen were killed. The protestors believed that companies exploiting oil and gas had done nothing to help the community (Okonta, 2000).

This ideology of all resources belong to all people in the community stems from the fact that the people of Ghana have from time immemorial practiced a communal way of living where the resources are controlled by chiefs and shared by all. Also, the country has partially adopted some level of socialism which was propagated by the first president, His Excellency Kwame Nkrumah. Therefore economists are right when they classify Ghana's economic system as mixed economy because it continues to holds on to the principles of state property ownership. The country controls greater number of firms and leaving very few for private individuals. In fact the issue of the state natural resources and reserves belong to all is one of the numerous problems that has led to civil and tribal wars in Africa in general. Conflict arises when someone or a certain group feels they are not getting their fair share of the national cake. It is one of the uncertainties that create fear in investors and has deprived Africa in general from being industrialized and also dissuades many foreign direct investments.

To curb the unacceptable behavior of citizens, such as holding firms and their workers for ransom and unnecessary uprising, it is imperative that government, parliament and opinion leaders tell their people that the investment are usually made by individuals and therefore the individuals are entitled to enjoy the profits of their deeds. However, it is the responsibility for government and chiefs to use the revenue from taxes and royalties for the development of education, social amenities and infrastructure in order to improve the lives of the citizens.

The GNPC strives to maintain Ghana's position and momentum for oil and gas interest, in order to attract both local and foreign investors. The GNPC has been able to prepare an attractive contract, lease and regulatory framework, agreed on by the government, but still needs final approval by the parliament of the Republic of Ghana to take full effect.

As the country attempts to enter into an agreement with a production firm or firms, it is the hope of the citizens that certain bad attitudes exhibited by the government and civil servants will be halted. The disturbing behaviors by government through its ministries have most of the time influenced bidding of contracts for their parochial interest and not the country's. It is usually exhibited as competitors paying bribes or attempting to corrupt officials when bidding for contracts or leases as many companies from various countries try to win the bid to exploit the country's oil and gas. This uncalled-for attitude needs to be halted. It is expected that government allows due process to take its course for competitive bidding so as to yield a better result.

Cronyism and nepotism on the part of government is also another important issue to address if we expect citizens to behave decently and peacefully. Often, Government appoints incompetent people to head ministries and top corporations because they are from the same political party or they are from their family. Eventually they collapse their firms to the detriment of the nation. It is expected that Ghana takes a conscious effort to factor all these in their critical decisions whenever a firm wants to undertake oil and gas production through the country's administrative process.

Chapter Three

3.0 Traditional Capital Budget Methods

Capital budgeting has several meanings; however the definition in this context is the process of deciding whether or not to commit funds or resources to a project whose benefits will spread out over a long period of time. Olsson quoted a more specific definition of capital budgeting from (Bierman & Smidt, 1993) as " a multi-disciplinary activity that includes searching for new and more profitable investment proposals, investigating engineering and marketing considerations to predict the consequences of accepting the investment, and making economic analyses to determine the profit potential of each investment proposal"(Olsson, 2003).

There are five primary methods used in making capital budgeting decisions which have proven to be very popular. These methods are usually called the traditional approach and are: net present value, pay back, internal rate of return, profitability index and decision tree analysis.

It is important to note that all these methods deal with cash flows over times that are critical part of analyzing any project. The cash flow has two main components, which are the cash outflows and the cash inflows. The money which a firm uses to fund a project is the cash outflow and the money or return which a project yields is cash inflow. The accuracy of the analysis mostly depends on the predictions about the cash outflows and the cash inflows and they are usually done through forecast methods like time series analysis, regression analysis, simulation scenario analysis and others.

3.1 Forecasting Cash Flows

All valuation methods use the cash flows and therefore the accuracy of any analysis is linked to the estimate of the cash flows. This implies that when cash flows are forecasted accurately there is a lower margin of error for the analysis. Forecasting is predicting what is going to occur in the future, which may be based on historical data or speculation when no current data exist. The prediction that is done from historic data is said to be quantitative forecasting. This is done through techniques called time series analysis and regression analysis. On the hand, forecasting using speculation is done by methods such as Delphi, expert opinion and others.

3.2 Discount Rate

In capital investment decisions the earnings from competing opportunities are future cash flows spread over time from the various projects. Due to this reason there must be an appropriate way of comparing the amount that will be earned in the future from the respective projects. Bringing the future cash flows to today's value makes it easy for comparison and interpretation. The system of comparison is called time value of money or discounted cash flow method.

In view of this, any economic evaluation primarily uses the discount rate to convert all future cash flows to present day value for appropriate comparison and interpretation. The discount rate is seen to be an esoteric and theoretical issue that is very hard to assign to a project that is undergoing evaluation. Nonetheless, analysts have to be more successful in using the correct discount rate and be able to show the pragmatic reasons why a certain rate was used.

There are generally three accepted methods for determining a discount rate in the oil industry: weighted average cost of capital, market surveys, and oil and gas sales analyses. Undoubtedly, the discount rate is the most difficult value to determine as mentioned consistently in this paper. In spite of this difficulty, the Texas Comptroller's Property Tax Division (PTD) has been able to calculate discount rate based on the overall mean Weighted Average Cost of Capital (WACC) of many petroleum companies which are listed on the New York Stock Exchange (NYSE) or Over the Counter (OTC) Market. The WACC is calculated by common expression shown as

$$WACC = W_d K_d (1-T) + W_e K_e + W_{pe} K_{pe} \ldots\ldots\ldots\ldots \text{eqn (1)}$$

Where

W_d is the weight of debt

W_e is the weight of equity

W_{pe} is the weight of preferred equity

K_e is the cost of common equity

K_d is the cost of debt

K_{pe} is the cost of preferred equity

T is the effective tax rate

The PTD grouped these companies into two main categories which are integrated and non-integrated petroleum companies. In 2004, the PTD compiled financial data for 21 integrated and non-integrated petroleum companies to calculate the WACC for each company.

The overall average of WACC for the 21 companies was 14.97 percent with a standard deviation of 1.29 percent. The PTD establishes the base discount rate of 14.97 percent and by adding some percentage points usually two points to the WACC. The added two points is known as the hurdle rate and accounts for a base amount of risk inherent in all petroleum properties.

The base discount rate may further be adjusted to show a wide variety of individual property specific risk attribute such as a lease. In a single completion leases there is a greater chance of early abandonment since the leases do not show any potential for production from additional zones in a single well bore. Therefore, one point is added to the established base WACC. Also, offshore leases have greater production and economic risks than those of onshore leases and such leases require two points upward adjustment to the base WACC (Strayhorn, 2006).

The PTD usually reconciles its calculated discount rate with that of Western States Petroleum Association and the Society of Petroleum Evaluation Engineers. PTD concludes that the discount rate ranges between 16.97 to 22.55 percent in 2005 and it is suited for petroleum appraisal based on the WACC results, market survey, and sales analyses (Strayhorn, 2006).

3.3 Advantages and Disadvantages of Traditional Methods

Proponents of traditional methods have argued that using the traditional methods produces results that have an acceptable level of precision and that are economically rational. They are relatively simple to use, widely taught and accepted. The results from using traditional methods are the same regardless of risk preferences of investors.

The traditional methods use the discount rate to convert all future cash flows to today's value. The discount rate does not take into consideration the systematic risk of the market which is correlated with the cash flows (Triantis & Borison, 2001). There is no universal discount rate or standard method of setting a discount rate. This tends to subject evaluation of projects to all kinds of manipulation through the selection of a high or low discount rate (Michel, 2001).

Researchers have argued that using the same discount rate to bring all cash flows to present tend to underestimate the true value of a project(Bailey, Couet, Bhandari, Faiz, Srinivasan & Weed, 2003).

The traditional methods main shortcoming is the difficulty to accurately predict the future benefits and costs.

3.4 Traditional Methods

The five primary traditional methods can be explained as follow:

3.4.1 Net Present Value

Net Present Value (NPV) is one of the widely accepted appraisal method for valuing projects. It measures whether the project is worth doing or not in certain terms. In using NPV approach the expected future net cash flows for each period are discounted with a discount rate known, usually the weighted average cost of capital (WACC).

If the computed NPV value is greater than zero then investing in the project will be profitable. However, the project must be undertaken only if the WACC is less than the expected rate of return. When the computed NPV is equal to zero, it implies the firm is indifferent about the investment decision since it will add no monetary value to the firm (Such projects may be undertaken by governments for merely political reasons, such as creation of employment for its citizens). The NPV can be shown mathematically as

$$NPV = C_0 + PV \text{...........} eqn(2)$$

$$PV = \sum_{t}^{n} \frac{C_t}{(1+r_t)^t} \text{..........} eqn(3)$$

Where C_t is cash inflow at time (t)

r_t is discount rate

t is time

3.4.2 Payback Period

This refers to the time period over which an investment is able to repay the amount committed into the project. It intuitively measures the time span needed for an investor to recoup the money invested into a project. This method is widely used to evaluate a project's viability. A typical conclusion usually drawn is that projects with shorter payback period are preferable to projects with long payback periods.

Although, this method of valuation is widely used, it has come under serious criticism due to its limitations and flaws. Some of its limitations are: it does not account for the time value of money, risk or other important considerations such as the opportunity cost of capital. Analysts in favor of this method of valuation have made an effort to incorporate time value of money into their calculation and have changed the name to discounted payback method. Yet, it retains short comings that need to be watched carefully. The discounted payback method for valuing a project does not look at the cash flows beyond when the amount invested is recovered. Since there can be negative cash inflows after the payment of the capital invested, it does not account for the true profitability of the investment. The approach can be illustrated below in Tables 3, 4 and 5.

In Table 2 the payback period is two years, since all money committed into the investment is recouped at end of the second year without considering the time value of money.

Table 2. Showing a payback period of 2 years

Year	0	1	2	3
Cash flows	-100,000	50,000	50,000	50,000

Similarly Table 3 also clearly shows that the total amount committed is regained at the end of the second year taking the time value of money into account.

Table 3. Showing discounted payback period of 2 years

Year	0	1	2	3
Cash flows	-100,000	55,000	60,500	61,000
Discounted cash flow @ 10%	-100,000	50,000	50,000	45,830.20

Table 4 depicts one of the problems of the payback method. The payback period is two years however an enormous loss is incurred after the second year. Indeed, due to this problem the payback method is only recommended for breaking ties between numerous projects when they all have same net present value.

Table 4. Showing payback period of 2 years and showing a flaw in the method

Year	0	1	2	3
Cash flow	-100,000	55,000	60,500	-1,000

3.4.3 Internal Rate of Return

This is the capital investment tool often used by management to decide whether firm should undertake a project. It is defined mathematically as the rate that sets the net present value to zero of a series of cash flows generated by a project. The project is considered to be worth doing when the internal rate of return is greater than the hurdle rate. The hurdle rate is the cost of capital usually referred as the minimum acceptable rate of return. The limitation of this approach is that whenever cash flow series is expected to have multiple signs then analysts may encounter more than one IRR. It may also be difficult to compute the IRR and therefore there will be no basis for the investors to make any decision. Find the IRR such that:

$$NPV= \quad C_0 + \sum_t^n \frac{C_t}{(1+IRR)^t} = 0....................eqn(4)$$

3.4.4 Profitability index (Cost-Benefit Analysis)

Another popularly known method used for evaluating projects is called the profitability index or cost-benefit analysis. In using this approach, the expected cash inflows and cash outflows are forecasted and discounted to their respective present values with appropriate discount rate. The cash inflows are considered to be the benefits and the cash outflows as the costs.

From the economists' point of view one should look at more than the cash inflows and cash outflows as benefits and costs respectively. The analyst can place monetary value on certain things such as creation of employment and acceleration of the economy as benefits, and pollution, environmental and health problems which are caused or induced by the project as costs. From such perspective, management that is in charge of government projects is encouraged to undertake the project if benefits outweigh the costs when employment creation or acceleration of the economy have been included in the valuation. The profitability index is a ratio of benefits to the costs. When it is greater than one in this perspective projects are viable to be undertaken. It is shown mathematically in equation 5.

$$PI = \frac{PV(benefits)}{PV(\cos ts)} \text{............} eqn(5)$$

$$PI = \frac{\sum_{t}^{n} \frac{CIF}{(1+r)^t}}{\sum_{t}^{n} \frac{COF}{(1+r)^t}}$$

Where

CIF is cash inflows

COF is cash outflows

3.4.5 Decision Tree Analysis

This is a decision tool for valuing a project which uses a graphical model that incorporates probability of strategy, resource costs and utility. The decision tree makes use of conditional probability to determine the best strategy to attain a certain target. Popularity of the decision tree for analyzing project is due to the following: it is very simple to understand and to interpret. The decision tree method of evaluation gives management a clear understanding of capital budgeting.

Decision tree analysis can be combined with other decision techniques to analyze many investment projects particularly when uncertainty is incorporated in the decision at discrete points. The decision tree helps in optimization of an investment portfolio. The interesting thing about decision tree analysis is that it attempts to capture some level of flexibility by incorporating probable events and the consequences of management decisions into the valuation.

The decision tree is another useful technique for modeling foregone earnings and intermediate cash flows when option-based models are not able to do so.

In spite of the many strengths of decision tree analysis, there are quite a few weaknesses that need to be stated and any user must be very circumspect when using this technique. The weaknesses of the decision tree analysis are that when evaluating a project with this approach, subjective probabilities and a risk adjusted discount rate are usually applied. Although it may capture both the time and risk preference of the investor, it is not appropriate when many options are present in the investment evaluation.

Chapter Four

4.0 Project Uncertainty and Real Option Analysis

A decision to invest in a potential oil field for development demands a thorough analysis. The analysis could be based on any of three main factors. The three factors are technical requirements, economic quality and market for the reserve. Financial decisions for developing a petroleum field can be made with two different methods. These methods are traditional approach and real options analysis.

The decisions by the traditional methods of evaluating oil fields are based on deterministic market variables such as cost and revenue. This method assumes a predetermined scenario that represents the future of the project. The decision is based on the comparison of the expenditures and revenues from the project.

Alternatively, a decision can be made by using the real options method for evaluating an oil field. This type of analysis for decision making is based on probabilistic market variable such as price and/ or technical variables such as the amount of oil and gas to be recovered. Modeling probabilistic market variables has recently gained popularity for decision making. This is because researchers have questioned the efficiency of the deterministic market variable approach for evaluating an oil field. They claim that interest-rate uncertainty can have an adverse effect on a petroleum project (Dickens & Lohrenz, 1996). The uncertainty in cash flows and production of oil and gas as a learning curve can induce management to abandon, delay or expand a project therefore justifying the use of real options for evaluation.

The oil industry is one of the capital intensive industries where real option analysis was first applied in a valuation process (Baugsto, 2005). The application of real option analysis in the petroleum industry has gained firm roots. Armstrong et al. (2004) showed the use of real options in the petroleum evaluation. For example they stated that Paddock et al. (1988) evaluated an offshore lease using real options, Ekern (1988) did an oil evaluation with this technique and Copeland et al (1990) presented a case study that involves an option to expand oil production (Armstrong et al, 2004). The investment analysis of offshore concessions in the Netherlands was evaluated by Smit (1997) with real options. Mikeal Pelet (2003) also modeled an evaluation of petroleum using real options and comparing results using geometric Brownian motion to mean-reversion with jumps.

Management flexibility in evaluating a petroleum project is very important and this is captured in real options. Lund (1999) used real options in valuing an offshore oil field by incorporating managerial flexibilities.

Researchers believe that results from real options analysis in evaluating a petroleum project are better than the traditional method. The reasons for this conclusion are: one, petroleum investments are irreversible but if a venture is unsuccessful management has the option to sell its physical and intangible assets for some salvage value. Two, uncertainties in the future values in cash flow tend to change the mode of operation in a petroleum development (Lima & Suslick, 2006).

4.1 Uncertainties

Uncertainty is the lack of exact knowledge of a project and one cannot tell the possible events and outcomes of the future concerning the venture. Uncertainty can be good or bad for a project. The state where the uncertainty is likely to yield an undesired, bad results or a significant loss is called risk. When analyzing projects concerning oil and gas, one is likely to encounter many uncertainties which include economic, technical and political.

Though uncertainties make it very difficult to undertake a project , they still allow a project to be undertaken should the investor and management devise prudent strategies, flexibilities, and options to minimize all risks and take advantage of favorable upside uncertainties.

4.1.1 Economic Uncertainty

Market variables such as the price of oil and gas, interest rate, and currency exchange rate are economic uncertainties that greatly affect the viability of a project. Another important factor is that the state of the targeted market economy that is where the commodities are intended to be sold is always an uncertain factor. An important question to be asked is whether consumers have the purchasing power to be able to buy the commodity. These economic factors are very volatile and correlate with the general movement of the economy.

Uncertainty can be favorable when the price of oil and gas increases and the corresponding increase in purchasing power generates higher cash inflow. However, the economic variables will not be favorable to the project with a significant increase in interest rate on debt or with a large devaluation of the currency use in operation which will tend to increase cash outflow for the project underway.

4.1.2 Technical Uncertainty

The most difficult aspect of any oil and gas production project is the prediction of the amount of the resource available in the formation. The geologic nature of the formation is a key factor to deal with during the production of oil and gas since it determines the drilling program. When the drilling program is not structured properly it can lead to a dramatic loss of equipment as well as human life as result of stuck pipes and blowout respectively.

There may also be geologic uncertainties that can be favorable to the project. In the case of Ghana National Petroleum Corporation in 2007, the total estimated recovery of oil was initially 500 million barrels. Additional research and development has proven an increase to 2 billion barrels in 2008. Although the down side of the geologic formation pertaining to discovery has not been mentioned, it is necessary that serious precautions be put into place to curb any associated risk.

The potential production of the oil and gas that is being evaluated is offshore of Ghana; the technical certainties that need attention are oil spill and blowout. Adequate, provisions must be put in place because if any of these scenarios should occur, it would plunge the venture into unprecedented loss and cause collapse of production.

4.1.3 Political Uncertainty

Investors deciding to undertake a foreign investment need to consider political uncertainty and the likelihood of affecting their business. Firms encounter political uncertainty and complexity especially in the developing countries. These uncertainties and complexities are risks that range across economic, financial, legal and social conditions of the foreign country. In general risk from political uncertainty can be grouped onto two categories. First, there are risks that may not be directly caused by the government such as war, uprising of certain group, or other forms of violence. Second, there are risks that are caused through government policies, for example export and import restrictions, tariffs and taxes, price control, expropriation, devaluation of currency and other foreign exchange control.

Political risks stem from government policies which are exhibited through the national economy and social structures within the country. The host government tends to create risk for the affecting firm that can be manifested through its policies, laws, regulations and administrative pronouncements. They impose implicit transfer risk to firms in their country in many ways. It is sometimes evident when the government restricts the firm from sending remittance of earning or repatriation of profits to the parent firm. Another political risk that can affect foreign firms is operational risk. It is seen when government require the majority of employees to be hired for the operation from the country (or local area), but there may not be enough skilled workers as needed by the firm. Government policies at times pose serious problems to the firm when it is made to go through difficult work permit procedures for employing competent worker who do not come from the operating country.

The worst among the numerous risks is expropriation by government, in which government takes control of the firm by force and pays little compensation or nothing at all to the original owners of the firm. The act is usually exhibited by military takeovers in destabilized countries. It is an unacceptable behavior but may be encountered.

Governments can sometimes pass laws to prevent proven oil and gas reserves and resources from being explored and produced due to environmental threats to the country, even when a firm has already acquired a lease for its operations. For example, the U.S Congress has enacted moratoriums on drilling and exploration in areas along the coasts of some states. These policies are intended to protect coastlines from even unintentional oil spills, although the Mineral Management Service estimates that there is an approximate 76 billion barrels of oil in the undiscovered fields offshore in the U.S. outer continental shelf (Jarmon & Anderson, 2007).

However, government actions can also be affirmative and can have a positive impact on a project. The positive steps a government takes to aid companies can be seen in term of tax exemptions for some number of years, or tax reductions which decrease the cash out flows of the firm which may result a corresponding increase in profit.

Chapter Five

5.0 Real Options Theory

Although traditional methods of valuation are widely used for evaluating many projects, Professor Stewart Myers invented Real options analysis in 1977 in response to the many pitfalls of the traditional valuation methods. Real options analysis has gained popularity due its numerous advantages over the traditional methods. A Real option is a right but not an obligation of an investor to implement a strategy or reject a strategy when undertaking a business decision. This is a type of option that is vested in management for a capital investment decision when they consider undertaking a project.

Real options analysis is a fairly new method for evaluating projects such as oil and gas production, which is an irreversible decision and subject to high uncertainty. This procedure for project analysis is an extension of option pricing techniques that are mostly used in the financial industry and has drawn its fundamental principle from the famous Black-Scholes model. In real options people invest in real assets while financial options are invested in financial assets such as stocks. The two seem to be similar because in both cases there is a right conferred on the holder, but not an obligation to undertake certain actions in the future.

Contrary to the traditional methods for evaluating projects that are based on fixed estimates of costs and revenues and a predetermined scenario, the real options analysis centers on the inherent managerial flexibility in the project. It factors in the likely real world uncertainties that may be encountered as the project is continuing. This embedded flexibility is the reason that management can sometimes take advantage of upside value in order to add value, or attempt to mitigate the downside (which is likely to pose risk to the business) and eventually reducing any catastrophe that may befall the project.

There are several options available for real options analysis that are intended to increase the flexibility and value associated with different kinds of strategic decisions within a firm for a project that is being undertaken. The most popular options are options to invest in the future, option to abandon, time-to build options, options to expand, options to shut down, options to restart, options to switch, growth options and contract options. Again, most investment decisions combine various options to maximize their flexibility, value and profit.

Although analysts are encouraged to use real option in their evaluations, projects must satisfy conditions such as:

a) A financial model: there should be a financial model for the project such as an existing discounted cash flow model. This is because real options analysis builds on an existing tried and tested method of current financial model.

b) Uncertainties: the option value is meaningless if there is no uncertainty and it comes back to the traditional method (specifically the discounted cash flow model). This implies that there must be uncertainties that influence management decisions before one could use real options.

c) Management must have strategic flexibility. Real options can be used when management can create credible, intelligent and implementable options.

5.1 Fundamental Assumptions of Real Options Analysis

In using real options for valuating a project basic assumptions are applied. Firstly, the market is considered to be frictionless which implies that: the discount rate is considered to be risk free and it is assumed to be constant over the entire life of the project. Also asset prices move stochastically in a Wiener process.

5.2 Input variables for calculating Real options

When evaluating a project with real options analysis, the various input variables that are needed for the valuation are present value of the underlying asset, time to maturity, volatility, cost of investment and the risk-free rate of return.

Present value of the underlying asset (S)

It is the value of project, investment or acquisition. When value of fundamental asset moves up, so does its call option. In real options owners can raise the value of the underlying assets while in financial options owners cannot.

Time to maturity (T)

This is the time for the option to expire. As the time to maturity increases, then the value of the option rises.

Volatility (σ)

The value of an option increases as the riskiness of the underlying asset increases. This is because the payoffs of the option are proportional to the value of the underlying asset exceeding its exercise price, in which case the probability increases with the volatility of the underlying asset.

Cost of investment(X)

It is the amount of money committed to undertake the option should one be buying the asset (call option) or one is receiving the money (put option). As the exercise price of the option increases, then the value of call option decreases and the put option increases.

Risk-free rate of return

This is the yield that is expected from a "risk-less' security with the same time of expiration of the investment, and it is the discount rate used to value an option. Indeed, as the risk free rate goes up or down, the value of the option also increases or decreases accordingly.

5.3 Price volatility

The real options analysis uses price volatility to evaluate a project. Some section of analysts believe that prices of oil and gas move stochastically in Geometric Brownian Motion (GBM) and others suggest that prices move in Mean-Reverting Motion (MRM). Analysts are divided between the use of Geometric Brownian Motion and Mean-Reverting Motion which calls for more research for a better description of price trends.

5.3.1 Geometric Brownian Motion (GBM)

The GBM is the process where the price of oil and gas move up or down in the long-run. GBM is also called drifted random walk model. It is the well known stochastic process in financial economics although it has some pit falls (Dias & Rocha, 1999). The price of oil moves in a stochastic differential equation as in equation 6.

$dP = \alpha_p Pdt + \sigma_p Pd_z$ ....eqn (6)

Where α_p is the growth rate

σ_p is the instantaneous volatility

d_z is the Wiener increment

t is time

P is price

5.3.2 Mean-Reverting Motion (MRM)

Mean-reverting motion assumes that the price of oil and gas cannot move upward or downward forever but revolves around a certain long-range mean value. Proponents of Mean-Reverting Motion reject the random walk of oil and gas prices. They point out that oil and gas prices exhibit a Mean-Reverting-Motion in the long-run equilibrium, though it is slow (Pelet, 2003). In the mean-reverting motion, price of oil moves stochastically in a differential equation:

$dP = \eta(P_m - P)dt + \sigma d_z$ ...... eqn(7)

Where η is reversion speed of price

P_m is the long-run average price

σ is volatility

d_z is the Wiener's increment

5.4 Debate about Real Options Analysis

In spite of the embedded flexibility which makes real options analysis a useful tool for evaluating projects, there are several criticisms of it. Critics say that real options analysis is purely theoretical and has no practical application in the business realm (Worner et al). Critics have also raised doubts about real options, saying that it is another way of increasing the value of a project that is not worth doing. By using real options valuation for capital budgeting decision, analysts end up choosing projects that have relatively large risks. For example, Doug Fears, CFO of Helmerich & Payne Inc. in Tulsa admits that real options might lead to overestimation of capital investment that will cause firms to undertake risks that need not be taken (Mintz, 1999).

However, Mun has a diametrically opposite opinion about this criticism. He claims that real option analysis has a pragmatic application with the use of Real Options Valuation's Super Lattice Solver software which he has introduced as a system for solving options for both financial and real options. This software has been embraced by many firms. Mun attempts to refute the assertions made by opponents of real options. Mun claims that if a project has strategic options with high uncertainties, then it is appropriate to incorporate or create several of those options such as delay, expansion, abandon, etc in the valuation so as to reduce and hedge the downside risk and taking advantage of upside of uncertainty (Mun, 2005). He then goes on to say that if a project has significant strategic options but analyst refuse to incorporate them in the evaluation, the project might not be properly estimated and money might be lost. CEO Ray Bingham claims that real option analysis sheds more light on uncertainties that are likely to befall an investment. In his view, using real option in valuing a project provides an important link between strategy and finance (Mintz, 1999).

5.5 Financial Options

In order to appreciate and gain full understanding of real options a basic knowledge of financial options and option pricing models is needed. It is in this perspective that the basic concepts of financial options as well as different evaluation methods have being introduced. Financial options are special contractual agreement conferring to the owner the right to buy or sell an asset at a fixed price on, or any time before a given day. European options are those that can only be exercised at the date of maturity while American options can be exercised at any time before the time of maturity. There are two kinds of options: calls and puts. A call option is the right of the owner to buy a specific asset at a fixed price at any time before a given date or on a particular date which is legally agreed. A put option is a legal contract that entitles to the owner the right to sell a specific asset at a fixed price at any before a given date or on a specified date.

5.6 Comparison of Real options with Financial options

The understanding of financial options theory is very important because in using real options we apply the principles of financial options to evaluate real or physical assets. Clearly, there are similarities between the two. For example, the position for a long call on the part of the holder for a call option is akin to real options' expansion principle. Due to the same fundamental theory behind the real options and financial options, both can be solved by using several methods including: closed-form solutions, partial differential equations, finite difference, binomial lattice and simulation but most firms have accepted real options valuation by the method of binomial lattice (Mun, 2005).

On the other hand, there are certain disparities between real options and financial options, although both real options and financial options have a time for maturing which is one of the similarities. However, the first difference between financial options and real options is that financial options deal with stocks prices which are of relatively low value and mature within a short time period as compared to real options which deals with real assets usually quantified in billions of dollars. The real options take into account other business parameters which take several years to mature and some have indefinite time to maturity. The parameters that are usually encountered by real options include free cash flow, market demand and commodity prices.

Second, there are times where financial options are manipulated by holders due to insider information, whereas it is impossible to do this in the case of real options. Again, in financial options, management assumptions and actions have no bearing on the valuation while management actions, strategies and flexibility add value to the valuation of real option asset.

Table 5 shows the relation between financial options and real options which can be applied in real situation such as oil and gas asset valuation.

Table 5. Relation between Financial options and Real options

Financial option (call option)	**Real option**	**Application in oil and gas investment**
Stock price	Present value of project's free cash flows	Present value of free cash flows of developed reserve
Exercise price	Expenditure required to acquire project assets	Investment Cost to develop the reserve
Time to maturity	Length of time the decision may be deferred or may expire	Time to expiration of investment right pertaining to the reserve
Risk-free rate	Time value of money	Time value of money discounted by WACC
Variance of return	Riskiness of project assets	Volatility of developed reserve

5.7 Methods for evaluating Financial and Real Options

There are several methods for evaluating financial and real options. These include Black-Scholes option pricing model, binomial, trinomial and multinomial models, partial differential technique, close form, etc. Notwithstanding the numerous methods mentioned, this paper uses only the Black-Scholes and binomial models because they require less mathematical rigor.

5.7.1 Black-Scholes Model

The Black-Scholes pricing model was formulated by Fisher Black who was later joined by Myron Scholes. Although the Black-Scholes model is the starting point for real options theory, the equation introduced by them was accepted by analysts due to how it could efficiently price options (Olsson, 2003). This model provides a fast and easy way to valuate an option (Triantis & Borison, 2001; Shockley, 2007). Black and Scholes formulated their equation from a heat transfer equation developed through a PhD dissertation by James Boness during his studies in the University of Chicago (Rubash, 2008)

The Black-Scholes formula for valuing financial and real options is given by equation 8 (Brealey, Myers &Allen) which really applies to European options on non dividend paying stocks; nonetheless there are several modifications that can be made to model other options such as American and the rest. The derivation of the formula involves complex mathematics which assumes stock prices follow a certain kind of path through time called stochastic order or Wiener process. The key features of a Wiener process are that the variables change continuously through time and these changes are normally distributed.

$C = N(d_1)S - N(d_2)Xe^{-rt}$ …………………eqn (8)

$P = X[1-N(d_2)]e^{-rt} - S[1-N(d_1)]$ …………...eqn (9)

$d_1 = \frac{\ln(S/X) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}}$ and $d_2 = d_1 - \sigma\sqrt{T}$ ……….eqn (10)

Where C is the current value of a call option

P is the current value of a put option

S is the current price of the underlying asset, or the present value of the future cash inflow.

σ is the volatility of the future cash inflow measured in percentage.

r is the risk free interest rate

N (d) is the cumulative standard normal distribution function

e is the base of natural logarithm

X is the option strike price

T is time to maturity

The underlying assumptions of this model are

- No arbitrage
- Prices are in a Geometric Brownian Motion/Mean-Reverting Motion
- The stock pays no dividends during the option's life

  Usually most companies pay dividends to their share holders whenever they make profit. The model assumes that dividend pay is negligible or, in better words approximately zero. This is a limitation of Black-Scholes model for pricing options.

- Market Efficiency

  Stock prices are considered to be moving in a stochastic order and this makes it very difficult for people (even with financial knowledge) to consistently predict the direction of the market or individual stock.

- European exercise terms are used

  The model assumes the option can only be exercised on the maturity date which is typical of a European option.

- No commissions are charged

  When participants are doing any transaction they usually pay some kind of fee or administrative charge. Though model acknowledges these charges or fees, but assumes that they are negligible and have no admissible impact on the results of option model.

- Returns are log normally distributed

  The returns on asset are considered to be distributed log normally.

- Interest rates remain constant and known

In order to make things simple and the option price model by Black-Scholes usable, interest rates are assumed to be constant and known. The Black-Scholes model uses the US Government Treasury Bill as the risk free rate.

The best way to gain appropriate insight and understanding of Black-Scholes model is go through an example. Professor Robert Kolb of the University of Miami presents a nice example (Kolb, 1993). He assumes the parameters as follows:

Stock price (S) = $ 100

Strike price (X) = $ 100

Time to maturity (T) = 1 year

Risk-free rate (r) =12 %

Volatility (σ) =10 %

After calculating d1 and d_2, the values of N_1 and N_2 are read respectively from the cumulative distribution function for the standard normal random variable table known as

Z-score. The corresponding N_1 and N_2 are 0.8944 and 0.8749 respectively. This implies that the call option price is given as

$C = N(d_1) S - N(d_2) X e^{-rt}$

$C = 100(.8944) - 100(.8749) e^{-(.12)1}$

$= \$ 11.84$

5.7.2 Binomial Option Model

The binomial method for valuing real options and financial options is a simple and intuitive approach. It was introduced because Black-Scholes model is not an exact way of valuing options. This model was introduced in 1979 by three the financial scholars John Cox, Stephen Ross and Mark Rubenstein (Wang, 2003).

It is has been explained that options like the American can be exercised even before the maturity date and the binomial approach models the time to maturity in discrete intervals (rather than continuous form as in Black-Scholes approach) to reflect the ability to exercise at any time. It is in this view that the editor of CFO magazine pointed out that Black-Scholes model overestimates options prices while the binomial gives a better estimate of option values due to its ability to divide time into discrete intervals (Teach, July 2003).

As the name implies, the binomial method assumes that the stock prices move stochastically either up or down relative to the initial price within the discrete time intervals via a binomial tree, sometimes known as lattice which is shown in figure 3. This method reflects the real life situation where stock prices always fluctuate. In this case every node on the tree represents a probable price of the underlying assets.

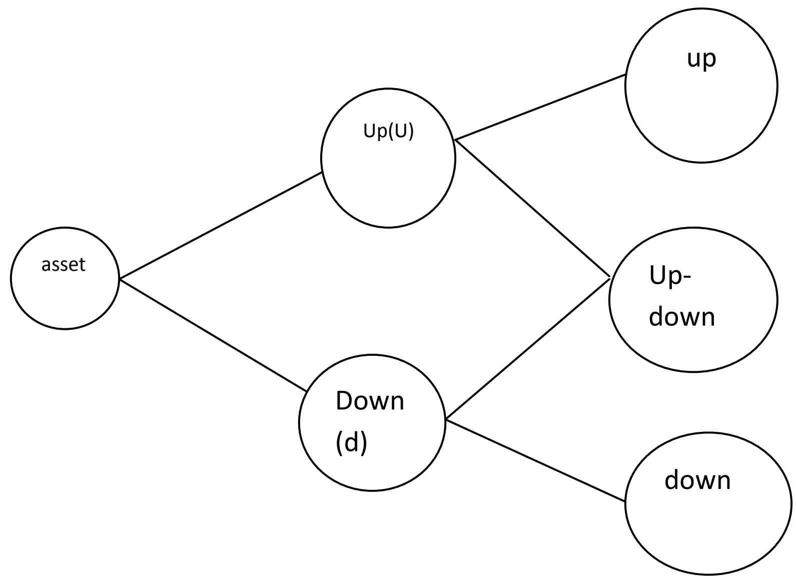

Figure 3. Binomial movement of asset price in two steps

The traditional methods used WACC to discount all cash flows to reflect the risk of a project. Nonetheless, this paper has underscored the biases and difficulties in using such a discount rate. Analysts suggest that it is proper to use risk free rate of return to discount all possible cash flows. The binomial option pricing model elucidates it by two approaches. First, through a portfolio of assets where cash flows are replicated in terms of the project a firm develops, which in simple terms are known as market-replicating portfolios (Borison, 2003). Second, computing the probabilities associated with the movement (up or down) of assets relative to the original which is discounted to the present value, and it's popularly known as risk-neutral probabilities.

a) The market replicating portfolio method

The replicating portfolio method eliminates the randomness of the option while equating the option to a risk-free portfolio that generates the same series of cash flows as the real asset that is being valued. This method is more complicated compared to risk-neutral probability approach.

b) The risk-neutral probabilities method

In this method, the underlying assumption is that the fair price of a derivative is equal to the expected value of its future payoff discounted by the risk-free rate. In this case the expected value is evaluated by using the option values from the nodes weighted by their respective probabilities.

The risk-neutrality probability up (u) and down (d) are given by equations 11& 12

$u = e^{\sigma\sqrt{T}}$ ....*eqn*(11)

d=1/u ……………………eqn (12)

The probability of stock price moving up is given by equation 13

$$p = \frac{e^{r\sqrt{T}} - d}{u - d}$$ ……………eqn (13)

The expected stock price is given by

$E(S_T) = pSu + (1-p)Sd$ …..eqn (14)

$E(S_T) = pS(u-d) + Sd$

By substituting p in equation 14

E (S_T) = $Se^{r\sqrt{T}}$ …………..eqn (15)

Where p is the probability

S is the stock price

T is time to maturity

r is the risk-free rate

The equation 15 shows that the price of an asset increases exponentially with the risk-free rate which is independent of the probabilities set. It is therefore expected that higher interest rate will encourage a person who is risk averse to undertake a project since the rudimentary assumption for this method is the risk-neutrality of the investor.

The main advantage of real options is that it integrates managerial flexibility into the valuation process, and in doing so helps in the decision making.

It does not ignore the risk pattern of any project that is likely to be encountered when the project is ongoing.

5.8 Pitfalls of Real Option

The real option method has also some fundamental pitfalls which are as follows; it assumes that underlying asset follows a geometric Brownian motion. Although this assumption seems mathematically convincing, it is very unrealistic (Mandron, 2006). The concept of asset volatility in real options is a major controversy, some analysts are for Geometric Brownian motion and others are for Mean-Reversion motion.

Real options method never looks at the cost volatility of investment. As price of oil increases it also pushes costs up therefore demonstrating the need to factor costs into real options.

Mandron (2006) argues that real options valuation assumes that a completed project pays a constant dividend which he claims is not true. Furthermore, Delphine (2003) also pointed out some other pitfalls, saying real option analysis assumes the market is perfect such that no transaction costs or taxes are incurred when exercising an option. This is completely false.

The computations for real option is cumbersome although softwares have been developed for solving them, yet analysts still need to have a strong mathematical ability.

Real option usually considers all uncertainties to be beneficial which might lead to increase of commitment to an investment that does not really deserve such initiative (Mandron, 2006).

Chapter Six

6.0 Problem Definition

The fundamental goal of this thesis is to evaluate the viability of the oil and gas find in Ghana. It is located in one of the sedimentary areas that are off shore. This area is called Cape Three Point; it is located in the western part of the country. The project is hoped to be commenced by the Ghanaian Government on her own or with other partners in 2009 if all goes as currently planned. The production phase is expected to last for a period of 50 years and more.

Although Cape Three Point has been established as a potential source for producing oil and gas, it is still risky since a commercial source of oil and gas in the area is not proven to be without uncertainty. Drilling wells for the production of oil and gas is complicated. It is not just a matter of drilling holes but also requires dealing with issues like geological formation, drilling fluid design and random variables such as weather conditions, tides waves etc.

Any company that decides to produce oil and gas from this area will be required to acquire rights over the undeveloped oilfield by making lease payments to the government. The firm that acquires the right through the payment of a lease to GNPC and its partner for the extensive exploratory work done must earn the right through competitive bidding. The extensive preparatory work done by GNPC and its partners involved a series of geophysical surveys, regional surveys and geologic reports which eventually led to the identification of the Cape Three Point resource.

6.1 Assumptions of this study

The valuation of this project is based on assumptions like projected future prices of crude oil and gas predicted by experts such as GNPC and also compared to the Energy Information Agency (EIA) in the U.S.

It will be very exciting for anybody producing oil and gas to hear that the prices of petroleum and its products are rising. However, the caution is that as the price in petroleum and its products increases, it brings an increase in cost such as labor, machinery, rigs and many others.

An increase in petroleum and its products can bring serious economic hardship which most of the times leads to upheavals and unnecessary uprising particularly in developing countries. For example, Fadel Gheit, a veteran Wall Street Analyst, said although the financial institutions are making billions of dollars profit, to some extent they are wrecking the global economy whenever there is a spike in oil price (Walsh, 2008). Therefore, in simple terms, as much as producers are happy about price increase they must think about the adverse effects. Dramatic increase in prices of all things wills eventually lead to inflation that will indeed affect the cost of production. Also, dramatic increase will bring economic hardship to people that might incite unscrupulous people to create tension and may increase the tendency of incurring unprecedented and unrecoverable cost. Therefore the analysis takes into account of costs as prices of oil and gas increase. The evaluation of the project is based on the predicted costs from evaluation experts from the GNPC.

One of the most difficult tasks in project evaluation is predicting the amount of oil and gas that can be extracted from the potential reserve or formation. This is because there may be an unexpected geologic stratigraphy which might make the amount of oil and gas to be produced be less than the expected and perhaps further generating complications that will increase cost. These will eventually affect the achievable cash flows. The evaluation assumes that all geologic information is tried and proven with minimum accepted deviation that requires just a few adjustments that can be handled by management.

The evaluation of the new oil and gas discovery will be done by both the traditional method and real options analysis. For an approximately accurate valuation for both traditional and real options approaches, it is very important that a timely and fairly accurate predicted WACC and risk-free rate are made. The WACC that is used to calculate the project practicality comes from PTD estimation of the WACC range of values with its modification based on the uncertainties surrounding the situation.

Ghana is one of the very stable countries in the sub-Sahara region of West Africa and is committed to the rule of law by democracy. In accordance with her democratic principles Ghana has enacted many acts. One of the acts is the Ghana Investment Promotion Council Act 478, which confers and guarantees to all enterprises and firms the freedom to transfer all dividend or net profit attributable to investment made by a firm back to headquarters. This same Act gives some of protection against expropriation which takes place in some developing countries through civil disobedience and military intervention in the political system. This Act is also buttressed by the country's strong commitment to laws enacted by the international community. Ghana clearly demonstrates its strong commitment by being one of the few signatories to the World Bank's Multilateral Investment Guarantee Agency.

Furthermore, the country has made efforts to position herself as the gateway to Africa to attract investors. Ghana therefore gives tax holidays for a period, after which a certain tax rate is surcharge on taxable income. Indeed, tax jurisdictions change over time and ultimately affect the tax shield enjoyed by firms that use debt in their capital structure. However, for simplicity reasons the evaluation assumes the tax rate and policies are going to stay the same throughout the period of production of the oil and gas.

Assuming all else remains constant including the policies put in place by Ghana, the project is will last for the anticipated time period. Since many risks have been dealt with through effective and efficient policies, investors will expect a certain return with theoretically no risk called the risk-free rate. The risk-free rate is the minimum rate of return investors expect when they commit their capital into investment. A risk- free rate of return 4.75 % is used for the evaluation of the project since the investor will accept any return on an investment greater than 4.75%. This interest rate of return is the return gained if invested in a UK bond (Walayet, 2008).

6.2 The Parameters for Evaluation

The evaluation assumes that:

- The reserve is 500 million barrels and it can be increased to 2 billion barrels
- The expected amount of oil that will be produced per day is at least of 15,000 barrels
- 210 thousand standard cubic feet of gas is expected to be produced per day.
- Average cost of drilling a well is US $ 40 million with expected escalation of 5% per annum.
- Capital expenditure will be about US $ 3.5 billion expected over 4 years.
- The labor, overhead and miscellaneous cost is pegged at US $ 200 million per annum.
- The risk-free rate is 4.75%.
- The weight average cost of capital is 18.97%
- The estimated number of wells to be drilled is between 40-50 wells with 10 % injection wells.

6.3 Data Analysis

6.3.1 Prediction of prices of oil and gas

One of the fundamental processes of evaluating a project using the traditional methods is to predict the revenue and costs. The prediction of prices is really a complex task. The prices of oil and gas are a function of demand, supply and certain random terms. The complexity of predicting a price is due to these random terms from economic and politic events. The random terms may include effects such as price floors or price fixing set by organizations such as OPEC, hype and games played by analysts, fear of shortage, wars and terrorist attacks.

6.3.2 Analyzing Project Viability using the Traditional Methods

Net Present Value Method

The feasibility of oil and gas production at Cape Three Point can be evaluated using traditional methods such as Net Present Value (NPV). NPV can be used to decide whether to invest in the production of oil and gas or not. The company will be better off investing if the NPV is positive.

Assume that the oil company possessing the lease produces at an average of 15000 barrels of oil and 210,000 scf gas per day with an operation life span of 50 years. Cash inflows are calculated for each year based on this amount of oil and gas, and the projected price of crude and gas.

Although the price of crude oil and gas are currently hovering around \$140 and \$13 (August, 2008) per barrel and square cubic feet respectively, from various economic analyses the bubble will eventually settle and the price of the petroleum and its products will fall. The time when the bubble will fall is not known by anyone and its prediction is impossible. Nonetheless, it is essential to incorporate this volatility factor of the market in this estimation. Proper understanding of volatility of the market is important to economic analysis, particularly where investment demands high capital such as this. Therefore, it behooves any analysts to be circumspect about market volatility and its likelihood in order not to overestimate or underestimate the project.

An average of $ 60 per barrel and $9 respectively are predicted by experts at the GNPC for the period of operation (It is close to the prediction by the Energy Information Agency (EIA) in the U.S. who also predicts an average of $ 65 per barrel). This, along with expected costs is used to compute revenue and net cash flows. This is then discounted to reflect time value of money using WACC. A WACC of 18.97 percent is used to discount all cash flows since it is an offshore lease (thus base discount rate plus two points upward adjustment).

Internal Rate of Return (IRR)

The project is evaluated using the internal rate of return in order to test the project viability. The calculated IRR is examined to determine whether it exceeds a minimally acceptable return by investors. This commonly known as the hurdle rate, above which investors are willing to undertake the project.

In calculating the IRR, it is substituted in place of the WACC in the formula used to calculate NPV and equated to zero.

Pay Back Period (PbP)

Every investor will at least want to know at what time the returns will repay the amount invested into a business. It is important to acknowledge that an early recoupment of money invested does not really tell whether a business is profitable or worth doing, which has been explained earlier in this paper. However, using PbP method in evaluating this project is relevant since all net free cash flows are positive. The discounted payback method is used to evaluate a project in order to take the time value of money into account.

Decision Trees Analysis (DTA)

The Decision Tree Analysis (DTA) is an excellent tool for evaluating a project such as production of oil and gas. It identifies several scenarios within the framework of management ability to improve the project viability and profitability, tied with their probabilities of success. It also helps analysts form a balanced picture of risks, their associated rewards and possible courses of action.

Basic economic principles tells us that money today is worth more than tomorrow, therefore if management decides to increase production it will increase their current revenue and reduce the life of the project. Therefore management has an option to increase revenue through an increase in production. Evaluating the project with the decision tree analysis from an expansion point of view is looking at the tradeoff of earning money quickly versus the chance that the price of oil will increase in the future which might also result in an increase in revenue. Thus management can also opt for deferment of production with the hope that prices will increase.

6.4 Real Options Methodology

Strategies for executing the project

Although the evaluation is centered on price volatility, there are other embedded features in real options. These include options such as starting production as a pilot plant to gain additional knowledge to help resolve major uncertainties about the oil from technical, economic and political considerations.

Management can actually expand the scale of production depending of the price of oil and gas. This is similar to a call option as explained earlier. The expansion option can be done using the firm's own capital or by contracting the expansion to a competent firm to achieve the set target.

Also, oil and gas need not be produced every day, month or year which is the flexibility real options emphasize. This can be exercised when revenues are not sufficient to cover variable operating costs. It might be very prudent not to operate continuously but rather to shut down intermittently.

Real options also capture the option to abandon when there is no hope for the project being profitable. This is called abandon for salvage value. For example if oil prices suffer a decline that cannot sustain production, management is not obliged to still continue producing.

Chapter Seven

7.0 Calculations and Results

7.1 Traditional Methods

7.1.1 Net Present Value

Scenario 1

In petroleum engineering, it is technically known that oil and gas recovery increases with increasing number of wells until a diminishing marginal point is reached. This implies in principle that there is an optimum number of wells to be drilled for efficient and effective oil and gas recovery. However, if the number of wells is too few, oil and gas recovered will be less efficient. This implies more time will be needed to extract the oil which delays revenue.

From the information gathered, about 40 to 50 wells may be needed for effective and efficient production in the Cape Three Point field. It is assumed that 50 wells are drilled to calculate the NPV.

Price of oil =$ 60 per barrel

Price of gas= $ 9/scf

Amount of oil produced = 15,000 bbl/day

Amount of gas produced = 210,000scf/day

Number of production weeks= 52

Number of production days = 5

Revenue from oil each year = $ 60*15000*(5*52)

= $ 234 Million

Revenue from gas in a year = $ 9*210,000*(5*52)

= $491.4 Million

Scenario I:NPV Calculation when all wells are drilled at once

Year	2009	2010	2011	2012	2013	2014	2015	2016
Revenue								
Oil			234	234	234	234	234	234
Gas			491	491	491	491	491	491
Cost of Production								
capital Investment	3500							
Drilling Cost	2000							
Labor, overhead&Msc.	200	200	200	200	200	200	200	200
Depreciation	70	70	70	70	70	70	70	70
EBIT	5770	270	455	455	455	455	455	455
Tax @35%	2019.5	94.5	159	159.3	159.3	159	159	159
Net Income	3750.5	176	296	295.8	295.8	296	296	296
Depreciation	70	70	70	70	70	70	70	70
Royalties			4.44	4.436	4.436	4.44	4.44	4.44
Net Cash flow	(3680.5)	(106)	361	361.3	361.3	361	361	361

Finding the present value for the annual cash inflow using the WACC of 18.97%:

The same net cash flow is assumed to continue until the end of production.

Depreciation is calculated using straight line method.

Royalties is calculated by finding 0.15 % of the Net income.

$$\text{The NPV} = -3680.5 - \frac{106}{(1+0.1897)} + \frac{366.01}{0.1897}\left(1 - \frac{1}{(1+0.1897)^{49}}\right)$$

= $-1.840 billion

Scenario II : NPV Calculation when a well is drilled at every year

Year	2009	2010	2011	2012	2013	2014	2015	2016
Revenue								
Oil			234	234	234	234	234	234
Gas			491	491	491	491	491	491
Cost of Production								
capital Investment	3500							
Drilling Cost	40	40	40	40	40	40	40	40
Labor, overhead&Msc.	200	200	200	200	200	200	200	200
Depreciation	70	70	70	70	70	70	70	70
EBIT	3810	310	495	495	495	495	495	495
Tax @35%	1333.5	109	173	173.3	173.3	173	173	173
Net Income	2476.5	202	322	321.8	321.8	322	322	322
Depreciation	70	70	70	70	70	70	70	70
Royalties			4.83	4.826	4.826	4.83	4.83	4.83
Net Cash flow	(2406.5)	(132)	387	386.9	386.9	387	387	387

$$\text{The NPV} = -2406.5 - \frac{132}{(1+0.1897)} + \frac{387.18}{0.1897}\left(1 - \frac{1}{(1+0.1897)^{49}}\right)$$

=$ - 476.43 Million

If all wells are not drilled at once but rather done in subsequent years it increases the NPV. Since it is assumed that the estimated cost of drilling today will not change but knowing that money today is more valuable than tomorrow it therefore implies that it would have been cheaper to drill the same well in preceding years. However, NPV is still negative.

Calculating NPV using Expected Value approach

Net Present Value is a well accepted method for evaluating projects. It has been mentioned in this paper and many others that it does not really incorporate all the associated uncertainties and management flexibility of the project. It is therefore very important that an analyst using NPV attempt to find ways to incorporate the uncertainties in the analysis, so scenario analysis can be run to test the viability of the project should situations change.

In this case the net present value is calculated using various prices of oil and gas with their probability of occurrence. The estimation is done for this example by assuming three different scenarios: low, medium and high prices of oil and gas, scenarios with different associated probabilities. First, different predicted prices of oil and gas are assigned with equal level of occurrence or probability that indicates the indifferent (base) case. The predicted prices for oil and gas are shown in Table 6.

Similarly, since the market is volatile and prices move stochastically to the current price, it is less likely for prices to remain extremely high since analysts believe the bubble will end. Indeed, there have been past situations when the market has seen prices skyrocket. Nonetheless, this analysis is done to see the feasibility of this project should the probabilities price of oil and gas not be equal. Therefore, in one scenario the analysis placed less emphasis on high price, and this is called the pessimistic case. This case is supported by economists who think that the market will eventually fall (Story, 2008). The prices of oil and gas with their respective probabilities are illustrated in Table 8.

On the other hand, some analysts also believe that the prices of oil and gas will keep rising as seen currently, therefore high probabilities are assigned to the prices of oil and gas depicting the optimistic case illustrated in Table 10.

Based on the argument raised in this research that when prices of oil and gas increase there will be an associated increase in average cost of drilling, labor, overhead and miscellaneous. The percentages of the increase in costs of production are predicted with various probabilities of occurrence which are shown in Tables 7, 9 and 11.

Scenario III: Indifferent case

Table 6. Expected prices of oil and gas with equal probabilities of occurrence

	Low price (USD) Probability= 0.33	Medium price (USD) Probability= 0.33	High price (USD) Probability=0.33
oil	60	80	170
gas	7	9	15

Table 7. Expected costs with equal probabilities occurrence

Average cost of drilling	5% increase, 50% Probability	10 % increase , 50% Probability
Labor, overhead and Misc.	6 % increase , 50% Probability	12 % increase, 50 % probability

Scenario IV: Pessimistic case

Table 8. Expected prices of oil and gas with great probability of prices staying at the medium.

	Low price(USD) Probability= 0.3	Medium(USD) Probability= 0.6	High price (USD) Probability= 0.1
oil	60	80	170
gas	7	9	15

Table 9. Expected cost with great probability of cost staying medium

Average cost of drilling	5 % increase, 70% Probability	10 % increase , 30% Probability
Labor, overhead and Misc.	6 % increase , 60% Probability	12 % increase, 40 % probability

Scenario VI: Optimistic case

Table 10. Expected prices of oil and gas with great probability of prices staying high

	Low price(USD) Probability= 0.1	Medium(USD) Probability= 0.3	High price (USD) Probability= 0.6
oil	60	80	170
gas	7	9	15

Table 11. Expected cost with great probability of cost staying high

Average cost of drilling	5% increase, 30% Probability	10%increase, 70% Probability
Labor, overhead and Misc.	6 % increase , 40% Probability	12 % increase, 60 % probability

NPV using expected value for NPV calculation

Scenario III estimation from Tables 6 & 7

The expected revenue from oil = 83*15000*5*52

= $323.7 million

The expected revenue from gas = 9*210,000*5*52

= $ 491.4 million

The expected cost of drilling for 50 wells = $ 2.14 billion

The expected cost of labor, overhead & Misc = $210.7 million

From the calculation at appendix A, the NPV = $ -1.695 billion

Scenario IV estimation from Tables 8 & 9

The expected revenue from oil = 103.3*15000*5*52

= $ 402.87 million

The expected revenue from gas = 10.3*210,000*5*52

= $562.38 million

The expected cost of drilling for 50 wells = $ 2.15 billion

The expected cost of labor, overhead & Misc = $218 million

From calculation at appendix B, NPV = $ -1.231 billion

Scenario V estimation from tables 10 & 11

The expected revenue from oil = 130*15000*5*52

= $515 million

The expected revenue from gas = 12.4*210,000*5*52

= $ 677 million

The expected cost of drilling for 50 wells = $ 2.17 billion

The expected cost of labor, overhead & Misc = $219 million

From calculation at appendix C, NPV = $ -486.84 million

Scenario VI: NPV calculation when prices of oil and gas hit all time high

The price of oil per barrel is assumed to be $ 200

The price of gas per scf is assumed to be $ 15

Labor, overhead and miscellaneous costs per annum is $ 250 million

Average total drilling cost for 50 wells is $ 2.5 billion

From calculation at appendix D, NPV is $ 530.77 million

7.1.2 Calculating the internal rate of return

From the cash flow statement in scenario I

$$0= -3680.5 - \frac{105.5}{(1+IRR)} + \frac{(366.01)}{IRR}(1-\frac{1}{(1+IRR)^{49}})$$

Therefore IRR= 9.6 %

7.1.3 Calculating the Payback Period

The payback period is 11 years without discounting the cash flows from scenario I. When the cash flows are discounted for determining the payback period, the cash inflow is not able to repay capital investment.

7.1.4 Decision Tree Analysis (DTA)

Expansion Approach

The firm decides to expand production, in which case the life of the project reduces to 30 years.

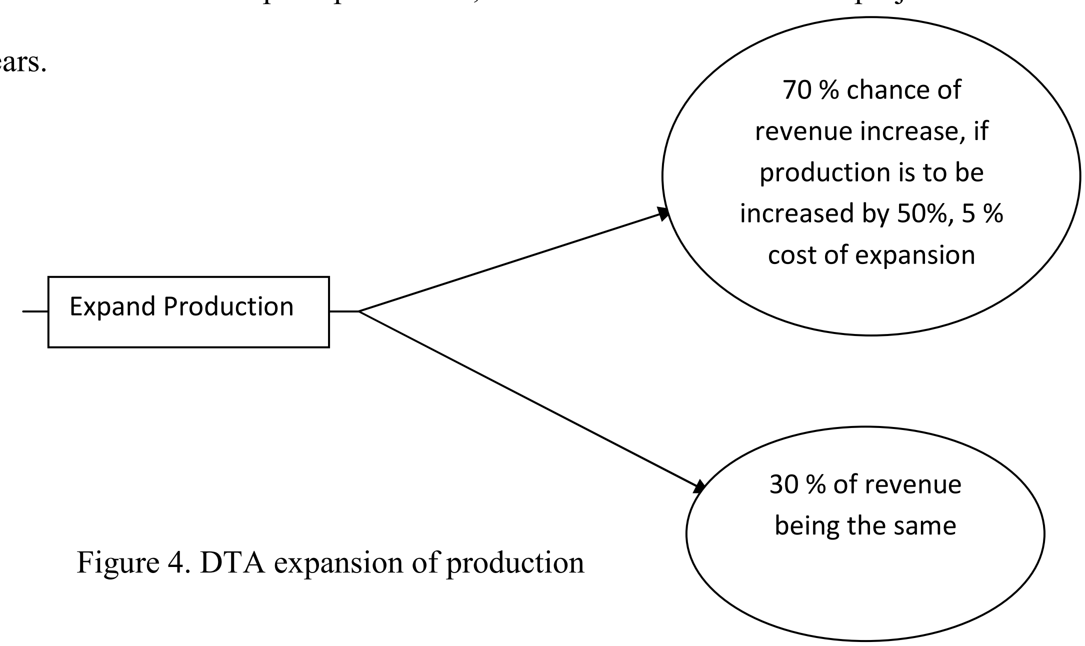

Figure 4. DTA expansion of production

Table 12: The result of DTA if expansion of production takes place

	Total Revenue	Capital investment	Labor, overhead & Misc	Drilling cost
Success	$32.64 billion	$ 3.675 billion	$ 6.3 billion	$2 billion
Failure	$ 21.76 billion	$ 3,675 billion	$ 6.3 billion	$2 billion

Expected NPV =

$$0.7\{-5.675+\frac{-6.3}{(1.1897)^{30}}+\frac{32.64}{(1.1897)^{30}}\}+0.3\{-5.675+\frac{-6.3}{(1.1897)^{30}}+\frac{21.76}{(1.1897)^{30}}\}$$

Expected NPV= $ - 5.547 billion

Deferral Approach

Assuming production of oil and gas in the oil field is deferred to the following year. Using price volatility, the DTA is used to illustrate management flexibility and the possible chances of the events happening.

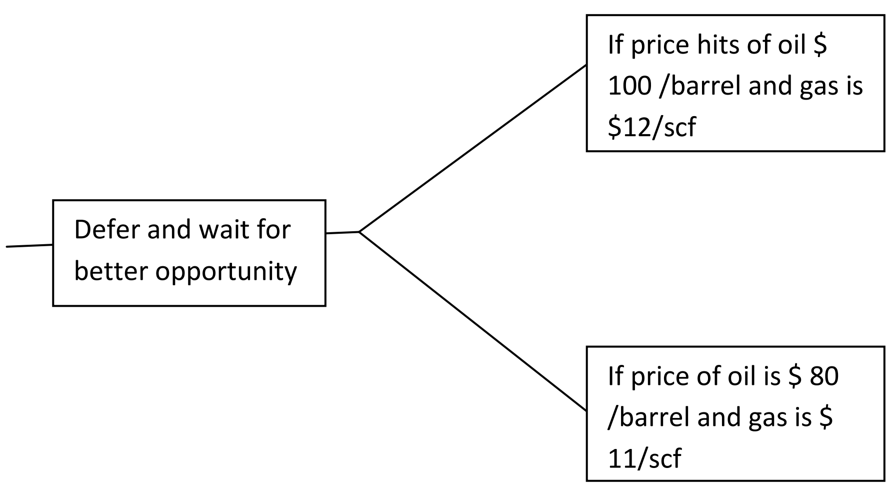

Figure 5. DTA deferment possibility of price

Table 13: Result of DTA when the project is deferred

	Revenue	Capital investment	Labor Cost	Drilling cost	Probability
Up State	$ 52.26 bn	$ 3.5 bn	$ 200 m p.a.	$2 billion	50%
Down State	$ 45.93bn	$ 3.5 bn	$ 200 m p.a.	$2 billion	50%

Expected NPV =

$$0.5\{-5.5+\frac{-10}{(1.1897)^{50}}+\frac{52.26}{(1.1897)^{50}}\}+0.5\{-5.5+\frac{-10}{(1.1897)^{50}}+\frac{45.93}{(1.1897)^{50}}\}$$

Expected NPV= $ - 5.49 billion

7.2 Real Option Analysis Calculation

Assumption

a) 500 million barrels in the field

b) 40% recovery of oil and gas during exploitation

7.2.1 Black-Scholes Method

Present value of the asset (S) = ($60 per barrel * 500 million barrel * 40 % recovery) + ($9*200 million scf * 40 % of recovery) - ($200 million for labor, overhead & Misc * 50 yrs) - $ 2 billion drilling cost) = $ 8.72 billion

Cost of investment (X) = $3.5 billion capital investment

Volatility (σ) = 30 %

Risk-free rate = 4.75 %

Time to maturity = 5 years

From equation 10

$$d_1 = \frac{Ln(\frac{8.72}{3.5}) + (0.0475 + \frac{1}{2} \times 0.3^2) \times 5}{0.3\sqrt{5}}$$

d_1= 2.050 and d_2= 1.379

The corresponding N_1 and N_2 from the cumulative distribution function for the standard normal random variable tables are 0.9798 and 0.9162 respectively

From equation 8

$C = 0.9798 * 8.72 - 0.9162*3.5e^{-0.0475*5} = \$ 601.51$ million

7.2.2 Binomial Option Model

Input Parameters		**Calculated Parameters**	
Annual risk-free rate	4.75%	Up movement per step	1.349
Current Value of underlying asset	$ 8.72 billion	Down movement per step	0.7408
Cost of investment	$ 3.5 billion	Risk neutral prob. (up)	0.5061
Time to expiration	5	Risk neutral prob. (down)	0.4938
Volatility	30%		
Number of steps per year	1		

Event tree of the underlying asset volatility

0	1	2	3	4	5
					38.9562
				28.8778	
			21.4068		21.3927
		15.8687		15.8582	
	11.7633		11.7555		11.7477
8.72		8.71424		8.70848	
	6.45978		6.45551		6.45124
		4.7854		4.78224	
			3.54503		3.54268
				2.62616	
					1.94546

$$\text{Exercise option} = \frac{\sum_{r}^{n} \frac{n!}{(n-r)!r!} p^{r}(1-P)^{r}[u^{r}d^{n-r}S - X]}{(1+r)^{n}} > 0$$

Year 1

$$\text{Exercise Option} = \frac{(0.5061*11.7633) + (0.4938*6.459) - 3.5}{(1+0.0475)} = \$5.228 Billion$$

Year 2

Exercise option

$$= \frac{(0.5061^{2}*15.8687) + (2*0.5061*0.4938) + (0.4938^{2}*4.7854) - 3.5}{(1+0.0475)^{2}} = \$5.5888 Billion$$

7.3 Summary of Results

Traditional Methods

1. Conservative price of oil and gas @ $ 60 per barrel and $ 9 per scf (Deterministic Approach)

Scenario	NPV Result	Conclusion
I	$ -1.84 Billion	Do not invest
II	$ -476.43 Million	Do not invest

Expected value approach (Probabilistic Approach)

Expectancy	NPV Result	Conclusion
Pessimistic	$ -1.695 Billion	Do not invest
Indifferent	$ -1.231 Billion	Do not invest
Optimistic	$- 486.84 Million	Do not invest

Prices of oil and gas hitting all time high

NPV Result	Conclusion
$ 530.77 Million	Invest

2. The discounted Payback Period is less than the acceptable time period, this implies the project should be done

3. The internal rate of return suggests the project should not be done, since it is less than the cost of capital.

4. Decision Tree Analysis

Situation	NPV Result	Conclusion
Expansion	$ - 5.547 Billion	Do not invest
Deferral	$ - 5.490 Billion	Do not invest

Real Options Analysis

1. Black-Scholes Method

The call price is $ 601.51 million. The cost of the lease must be less than the call price to make the decision to develop the oil and gas field be supportable.

2. Binomial Method

Table 14. Results of the Binomial decision tree using risk-neutral probability

Year	1	2	3	4	5
Value of option ($Bn)	5.228	5.588	5.703	5.68	5.188
Decision	invest	invest	invest	invest	invest

Chapter Eight

8.0 Discussion of Results

Comparison of traditional methods with real options

The calculation and results of this research showed that the project is not worth doing from the stand point the traditional methods analysis. This is because in all cases the NPV result is negative. It will only be worth doing when prices hit an all time high at $ 200 per barrel which most analysts believe the world economy has not got to that stage.

The Decision Tree Analysis is a better way of evaluating projects since it incorporates management flexibility in its calculation. Nonetheless, there is a shortfall regarding the inappropriate way of assigning discount rate and gave a negative NPV for the project evaluation.

On the other hand, the real options results suggest the project is viable due to its ability to correctly assign some value to management ability to defer, abandon, expand or contract an investment which increases the projects viability (Mauboussin, 1999). The real options counts on the future fortunes that might come to the project and will create opportunities. In real options estimation, investments with greater volatility can be promising, have high profitability and be worth doing. This is contrary to theory behind the traditional methods which deems such an investment very risky and low profitability by assigning higher discount rate that lowers the payoff, resulting in less desire to commitment to project investment.

The traditional methods are easy to understand and it is used by many analysts, but considered to be less robust than the real options method because real options factors management flexibility into the valuation. The differences between traditional method and real options are in risk treatment and management flexibility.

The traditional approach does not evaluate a project based on chance dependence or events that happen in the future, though the research used the probability of price moving up or down scenarios to test the project's feasibility. However, the real options valuation uses the possibility of better fortunes happening for the project to be undertaken.

The thought that real options analysis is going to replace NPV in the corporate finance toolkit is not true. This is because analysts have acknowledged how useful the NPV valuation approach is. It can be very helpful when evaluating a project with no options or where options do not create any value (Olsson, 2003). However, it must be emphasized that more accurate will result when using real options instead of the traditional approach when there are options with adequate value.

The motivation to use traditional methods comes from the fact that it is simple, easily understood by managers, while the real options is quite complicated, and may require advanced mathematical knowledge (though several software solutions have been introduced). Again, the binomial option method is gaining firm roots though it has shortfalls. It does well to take advantage of price volatility however it fails to recognize the possibility of the costs increasing. It is in this light that Insead and Levinthal question the integrity of real option analysis and insist that the cost of options that is subject to create change in the decision tree, must be included in the valuation (Insead & Levinthal, 2004).

Conclusion

It is important to realize that none of the capital budgeting decision-making tools gives an exact solution (Shenoy & Lander, 1999) since all methods of evaluation have some shortfalls. It therefore behooves analysts to be very careful in evaluating a project with any single method.

The results for the traditional methods are negative for the case study, which infers that the project should be rejected. However, the real option analysis results suggest that the investor should undertake the project.

Almost all traditional approaches suggest that a project is now or never, whereas the real options technique gives many options like deferring for better opportunities in the future. In real options, the management's flexibility for delay or defer a project for better future opportunities is important. This is an attempt to link strategy and finance, which is aimed to solve difficult problems that might be encountered. Nonetheless, the caution is that if the foregone cash flows from delaying the project are too significant that might reduce the benefit for waiting, and it is not worth it. Again, delaying a project is very delicate issue to deal with in a real world situation. For instance, if the firm's ability to delay a project is influenced by another firm's strategic interactions, then the firm's ability to delay is 'share' right. This right can result in economic barrier to entry which requires prudent game theory strategy for evaluation (Mahnovski, 2006).

In conclusion, since the assumption that all uncertainties are good is not true, it is important to not substitute NPV with real option but it should be seen as a complementary approach of evaluating a project.

Recommendation

The research suggests that the project should be valued with the real options technique. This is because the project falls under the following circumstances:

a. High uncertainty about its future

b. Large room for managerial flexibility

c. Most likely to acquire new information and technology

d. In the oil and gas business prices do not remain the same as the NPV method suggests for the entire period of the project. And when prices go down, managers readjust to make the oil and gas business profitable through numerous methods. Also, if prices remain stagnant managers have the flexibilities to map strategies to make the investment more profitable.

Ghana as whole has a monumental stake in the production of oil and gas at Cape Three Point. There will be several economic benefits the country will reap should a firm or the country decide to undertake oil and gas production. Some of these benefits include an increase in direct employment from this investment plus the multiple effect of employment that will also ensue.

Also the government expenditure on imports of petroleum and its products will decrease. This will help government to balance its budget and stop running at a deficit.

Furthermore, there will be large amount of gas from the production that can be used to power turbines for stable and reliable electricity. The advent of production to generate stable and reliable electricity will eventually attract foreign direct investment which is more likely to turn Ghana into a more industrialized country in the sub region of West Africa.

The lease to be acquired from GNPC to start production must be acquired through competitive bidding. However, this competitive bidding seems to be a very delicate issue for developing countries. This is because they receive financial and technical support from developed countries, which are often tied with conditions and trade terms. It is therefore imperative that when competitive bidding for the lease is hampered by such preconditions by any country, the government should not heighten the political risk of the operating firm.

Oil and gas production is critical to Ghana's revamping of the creeping economy. This can be achieved through a thorough monitoring of the company which gets the nod from the payment of the lease. The country must be very vigilant so that the firm does not indulge in any corrupt act such as understating its profit, tax evasion or others. The government must also be accountable to the people.

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Appendices

Appendix A

Scenario III: NPV Calculation with equal estimation of probabilities

Year	2009	2010	2011	2012	2013	2014	2015	2016
Revenue								
Oil			324	324	324	324	324	324
Gas			491	491	491	491	491	491
Cost of Production								
capital Investment	3500							
Drilling Cost	2140							
Labor, overhead&Msc.	210	210	210	210	210	210	210	210
Depreciation	70	70	70	70	70	70	70	70
Amortization								
Interest on Loan								
EBIT	5920	280	535	535	535	535	535	535
Tax @35%	2072	98	187	187	187	187	187	187
Net Income	3848	182	348	348	348	348	348	348
Depreciation	70	70	70	70	70	70	70	70
Royalties			5.22	5.22	5.22	5.22	5.22	5.22
Net Cash flow	(3778)	(112)	413	413	413	413	413	413

Appendix B

Scenario IV: NPV Calculation with high probability of prices staying medium

Year	2009	2010	2011	2012	2013	2014	2015	2016
Revenue								
Oil			402.9	402.9	402.9	402.9	402.9	402.9
Gas			562.4	562.4	562.4	562.4	562.4	562.4
Cost of Production								
capital Investment	3500							
Drilling Cost	2150							
Labor, overhead&Msc.	218	218	218	218	218	218	218	218
Depreciation	70	70	70	70	70	70	70	70
Amortization								
Interest on Loan								
EBIT	5938	288	677.3	677.3	677.3	677.3	677.3	677.3
Tax @35%	2078	100.8	237	237	237	237	237	237
Net Income	3860	187.2	440.2	440.2	440.2	440.2	440.2	440.2
Depreciation	70	70	70	70	70	70	70	70
Royalties			6.603	6.603	6.603	6.603	6.603	6.603
Net Cash flow	(3790)	(117)	503.6	503.6	503.6	503.6	503.6	503.6

Appendix C

Scenario V: NPV Calculation with high probability of prices staying high

Year	2009	2010	2011	2012	2013	2014	2015	2016
Revenue								
Oil			515	515	515	515	515	515
Gas			677	677	677	677	677	677
Cost of Production								
capital Investment	3500							
Drilling Cost	2170							
Labor, overhead &Msc.	219	219	219	219	219	219	219	219
Depreciation	70	70	70	70	70	70	70	70
EBIT	5959	289	903	903	903	903	903	903
Tax @35%	2085.7	101	316	316	316	316.1	316.1	316
Net Income	3873.4	188	587	587	587	587	587	587
Depreciation	70	70	70	70	70	70	70	70
Royalties			8.8	8.8	8.8	8.804	8.804	8.8
Net Cash flow	-3803	-118	648	648	648	648.1	648.1	648

Appendix D

Scenario VI: NPV Calculation when price of crude is $ 200 per barrel

Year	2009	2010	2011	2012	2013	2014	2015	2016
<u>Revenue</u>								
Oil			780	780	780	780	780	780
Gas			819	819	819	819	819	819
<u>Cost of Production</u>								
capital Investment	3500							
Drilling Cost	2500							
Labor, overhead&Msc.	250	250	250	250	250	250	250	250
Depreciation	70	70	70	70	70	70	70	70
EBIT	6320	320	1279	1279	1279	1279	1279	1279
Tax @35%	2212	112	448	448	448	447.7	447.7	448
Net Income	4108	208	831	831	831	831.4	831.4	831
Depreciation	70	70	70	70	70	70	70	70
Royalties			12.5	12.5	12.5	12.47	12.47	12.5
Net Cash flow	(4038)	(138)	889	889	889	888.9	888.9	889

Appendix E

Ghana National Petroleum Corporation

Private Mail Bag

Petroleum House

Community 1, Tema

Ghana.

16th October, 2008

To Whom It May Concern

Permission to use Information

I write on behave of the management of Ghana National Petroleum Corporation to given permission to Mr. Isaac Owusu-Ansah to used GNPC information regarding oil and gas industry with special reference to the Jubilee Field for his MSc. Thesis.

The following information/data were given to Mr. Isaac Owusu-Ansah in respect of his MSc. Thesis. Some of the information was taken from GNPC website with authorization from GNPC and data regarding the Jubilee Field directly from engineering department of Ghana National Petroleum Corporation (GNPC).

The information/data are as follows:

1. Activity maps showing the acreages in the sedimentary basins of Ghana (2 maps)

2. History of Oil exploration operations in Ghana

3. Jubilee Field data such as; Reserves; predicted daily oil production; Gas production; average cost of drilling a well and expected increase per annum; capital expenditure expected over 4 years; labor overheads and miscellaneous cost per annum; risk-free rate; the weight average cost of capital; estimated number of wells to be drilled for the project; average price of crude oil and gas used for economic analysis.

For any question please don’t hesitate to contact me.

Yours truly,

Albert Longdon-Nyewan

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