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Research Article

PROBABLISTIC EVALUATION OF ONSHORE MARGINALOIL FIELDS DEVELOPMENT IN NIGERIA

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ABSTRACT

The objective of the study is to assess the profitability indicators on onshore marginal oil field in Niger Delta region. The cash flow model was developed based on standard oil and gas project economics and the Nigerian fiscal framework. The analysis was carried out deterministically using economic indicators like the Net present value (NPV), the internal rate of return (IRR) and profitability index (P.I) and payback period (PBP). A probabilistic evaluation involving stochastic assessment of the deterministic single value (NPV, IRR, PI, and PBP) was carried out through MonteCarlo Simulation process using Oracle Crystal Ball Software. The deterministic model results obtained from the studies were a positive Net Present Value of $2.7 Million at a 14% discount rate which is positive and economically viable being an independent project. The Internal Rate of Return (IRR) is 20% which is also higher than the hurdle rate. The probabilistic evaluation shows that there is certainty of having a positive net present (NPV) and internal rate return of values far above the hurdle rate for investment in Nigeria. Oil price and tax rate are sensitive parameters in maximizing profitability. The study has demonstrated that onshore marginal field development in Nigeria is profitable. This will aid investor's decision making.

Key words: Onshore marginal field, sensitivity analysis deterministic approach, probabilistic evaluation

INTRODUCTION

Ayodele and Frimpong (2003) explained that marginal fields refer to oil fields that contain reserves that are not economical when produced by the major international oil companies but might be profitable if explored by indigenous entrepreneur due to their low overhead and operating cost.Marginal oil fields are generally unattractive to development due to economic, technical or strategic reasons. They are mainly located in areas that are very far from existing production facilities, investors find it difficult to develop this type of field because of it nature which when tied to economics lack attractiveness. According to Egbogah (2011) in Nigeria the challenges associated with most marginal field's development are numerous namely: economic/financial, technical, socio-political, ecological and environmental. For example the problem of multiple taxations by local, various agencies of government is affecting start-up of the asset being developed by marginal field operators in the country.Multiple taxations is a serious problem to the economic development of marginal of field because it increases the cost of operations for marginal field operations (Fatona, 2013).Marginal fields can be undeveloped discoveries, fields in production or abandoned fields. Because of the high risk involved in marginal field development it is necessary to understand the profitability metric in the economic analysis of marginal oil field development.

Aim and objectives of the study: This study investigates the profitability indicators of onshore marginal oil fields in Niger Delta in order to encourage private investment in marginal oil field. The specific objectives are:

- To build a deterministic cash flow model of the best option to obtain the profit indicators
- To further build a stochastic model of the deterministic output to handle the inherent risk associated with venture.
- To perform sensitivity analysis to identify the key variables affecting profitability of the program.
- To suggest incentives and economic conditions that will boost investment in marginal fields

LITERATURE REVIEW

Model backbone:

The economic model was performed through the industry valuation tool of discounted cash flow approach via the net present value, internal rate of return NPV/IRR and Monte Carlo simulation.

Economic Yardstick model equation:

Profitability Indicators:

These are the indicators under certainty that were used to determine the profitability of the venture

obtained from the model. These include the Net Present Value (NPV), internal rate of return (IRR), Present Value Ratio (PVR), Profitability Index (PI), and Pay Back Period (PBP) discussed below.

Net Present Value (NPV):

This is the sum of the present values of the individual annual net cash flow over the life time of the project. It is the most commonly used petroleum evaluation criterion for selecting projects. The decision to accept or reject the project depends on the value of the NPV, That is, if the NPV is less than zero (-NPV) the project is rejected while NPV more than zero (+NPV) leads to acceptance of the project. The equation used for the calculation of the NPV for end of year discounting is given below:

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t} \quad \text{.....2.1}$$

Where *NCF* is the Net cash flow, i is discount rate, $t$the current year and n is the project's economic lifein years.

For the purpose of this study, the mid-year discounting approach of computing the Net Present Value (NPV) was used because it gives a higher value of the NPV as cash flow transactions take place continuously or at least monthly; the mid-year will account for this as the average over the year (Mian 2011). Below is the equation used

$$NPV = \sum_{t=1}^{n} \frac{NCF}{(1+i)\wedge(t-0.5)} \quad \text{.....2.2}$$

Internal Rate of Return (IRR):

The internal rate of Return (IRR) is the discount rate at which the NPV of a project equals zero. Thus the IRR is the rate of return at which the PV of the future payoffs is equal to the initial cash outflow for the project. However the IRR is less useful than the NPV because sometimes a project may not have a unique IRR and in some cases an IRR may not even exist but it is to know the rate at which the initial investment is recovered and profit making starts.

Mathematically it is given as:

$$NPV = \sum_{0}^{n} \frac{NCF}{(1+i)\wedge(t-0.5)} = \text{.....2.3}$$

Where *NCF* is the Net cash flow, i is the IRR and t is the time in years.

The decision rule here is that, if the calculated IRR is greater than the discount rate at which the NPV was gotten, the project is accepted and rejected if the IRR is less than the discount rate. To make a decision on this uncertain situation, the IRR obtained from the deterministic model is compared with the desired discount rate.

Present Value Ratio (PVR):

The PVR is the ratio of NPV to the present value of capital investment

$$PVR = \frac{NPV}{PV\ of\ Capital\ \ Invested} \quad \text{.....2.4}$$

If the PVR of the incremental cash flow is greater than zero, the project is accepted and vice versa.

Profitability Index:

This is a profitability indicator that measures the present value benefits per capital invested. Typically suitable for investments with limited funds. It is a dimensionless ratio that shows the relative profitability of an investment. Mathematically, it is given by

$$PI = 1 + \frac{NPV}{PV\ of\ Capital\ \ Invested} \text{.....2.5}$$

$$PI = 1 + PVR \quad \text{.....2.6}$$

If the PI of the incremental cash flow is greater than 1, the project is accepted and vice versa.

Payback Period:

The payback period is the time at which the cumulative cash flow discounted or undiscounted becomes positive. The criterion answers the question of how long it will take to recover investments. It is an important yardstick to the investor as it shows the point where profit making starts and new capital generated from the project. Payback period also indicates the rate at which cash flows are generated early in the project. It can be calculated by interpolation or by using the equation given below:

$$PBP = Cum.-ve\ NPV\ Yrs + \frac{1}{+ve\ NPV - (-ve\ NPV)} * -(-ve\ NPV) \text{.....2.7}$$

If the project has a shorter payback period, it is accepted and vice versa.

MATERIALS AND METHODS

The methodology of this study is classified into two parts: technical and economic analysis. The technical analysis involves the application of decline curve analysis used in analysing declining production

rate and forecasting future production data while the economic analysis involves cash flow modelling, project profitability and sensitivity analysis using Monte Carlo simulation (Adamu et al 2013). From the past production data of an abandoned on-shore marginal oil field in Niger Delta a production profile was developed using decline curve analysis to determine the annual production rate and the project life span as a basis for cash flow analysis.

Risk Analysis:

The risk analysis tries to quantify uncertainty by treating uncertain input parameters of a problem as random variables, which are distributed according to quantifiable statistical distribution functions. In this study, the deterministic model was converted to a stochastic model through Monte Carlo simulation process using Oracle crystal ball software to quantify and characterize the risk and give a better estimate of the expected value.

a. Monte –Carlo Simulation Process

Monte Carlo simulation is a technique for modeling uncertainty that begins with the building of a deterministic spreadsheet model of a situation of interest to be analyzed. Through this process, the single model values are converted to random variables with large variability and making it possible to estimate the range of the model by producing large model runs to give statistical output for analysis. To achieve this, the following steps were used for the simulation.

- A spread sheet model was built to describe an uncertain situation of interest, in this case incremental cash flow model of the marginal field development project to obtain a value for Net Present Value (NPV), Internal Rate of Return (IRR), etc
- Assumptions for inputs with uncertainty were defined (e.g. oil price, CAPEX, OPEX, tax rate and cost inflation with triangular probability distributions for all)
- Defined a forecast and then ran a simulation on the model to randomly generate values of uncertain variables over and over to simulate the model output (e.g. NPV, IRR, PI,PVR and PBP)
- Analyzed the results, the output statistics (mean, variance, certain level, P_{10}, P_{50}, P_{90}etc) that show the entire range of all possible outcomes and the likelihood of the occurrence of each of them. The expected values of these outputs were then looked at as to give better information that guides investment decision making.

b. Sensitivity Analysis

For the purpose of this work, Tornado Chart and Spider Diagram are the tools employed for the sensitivity analysis. The influence of these variables (assumptions) on the forecast values was ranked in the degree of their impact as to guide the investor concern of the most influential variables on profitability.

Building the Economic Model:

The deterministic economic model was built in a Microsoft Excel Sheet using the parameters described above as input variables such as the ultimate recovery, initial production rate gotten from the decline curve analysis, oil price, initial investment, operating cost, inflation rate, royalty rate, tax rate and their respective equations. However, the process of obtaining the cash flow starts with obtaining a production profile, from this revenue generated yearly is obtained and cash spent yearly is also obtained. The cash received less cash spent is the Net Cash Flow (NCF). This cash flow model has no consideration for uncertainties in the input parameter that greatly affects the model output results like the NPV. Consequently, the profitability indicators cannot account for the inherent risk associated with the project in terms of decision making.

Production Profile:

This shows the trend of the daily production rate, annual production of the new well over the project life as a function of the initial production rate, ultimate recovery and decline rate. Below are the equations used for the computation of the production profile for the model.

$$Daily\ Prod. = Intial\ Prod.rate * (1 - decline\ rate)^t - 1.5 \dots \dots \dots Equ. 3.1$$

$$Year\ 1\ Production\ days = Days\ per\ year * year\ 1\ fraction \dots \dots . Equ. 3.2$$

$$Year\ 1\ Annual\ prod. = Yr\ 1\ Prod. days * Daily\ prod \dots \dots \dots \dots \dots . . Equ. 3.3$$

$$Annual\ prod. from\ Yr. 2 = Daily\ prod. * 360 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots Equ. 3.4$$

Case study of the Field:

This section discussed in details about the case study of field X(marginal field), decline curve analysis, data gathering, economic analysis, risk evaluation and sensitivity analysis. X Field is located in the south-eastern corner of the Niger Delta. The X field, was discovered in 1973 and operated by SACO. Well_A2 is the only string that ever produced from X Field and has been shut since May 1995. It started production in December 1973with initial oil rate of 162 stb/d and GOR of 1208 scf/stb and 0% water cut. The initial stock tank oil in place was estimated at 10.3 MMstb and at shut in, the cumulative production stood at 4.814 MMstb of oil, 6.35 Bscf of gas and 1.531 MMstb of water with oil production rate of 200stb/day. The oil recovery factor is currently 40.1%.The field was considered marginal due to the long years of abandonment.

No of Wells	1 (one) Well 03LS
Start of Production (SOP)	DEC 1973
End of Production (EOP)	May 1995
Initial oil Rate stb/day	162
Initial Gas oil Ratio (GOR) scf/stb	1208
Initial Water Cut. (%)	0.0
STOIIP (MMSTB)	10.3
CUM Oil Prod (mmstb)	4.814
CUM Gas Prod(Bscf)	6.35
CUM Water (MMSTB)	1.531
Present Recovery Factor (%)	40.1

Table 1: History of the field X

Decline curve analysis:

Decline curve analysis using production data is a powerful and convenient tool for forecasting the future production for wells, lease or reservoirs. However, there are several assumptions that that should be made before analyzing the production decline data with any degree of reliability. Utomako, et al (2015) opined that the assumption includes:

1. The production must have been stable over the period being analyzed, that is a flowing well must have been producing with a constant choke size or constant well head pressure. This indicate that the well must have been producing at a capacity under a given setoff condition.
2. Observed production decline should truly reflect the reservoir productivity and not be results of external causes such as change in productions, well head damage, production control, and well equipment failure.
3. Stable reservoir condition must prevail in order to extrapolate the decline curve with any degree of reliability.

The three types of production decline curve have commonly been used. They are: Constant percentages or exponential decline, hyperbolic decline and harmonic decline

Production profile was generated using the Petroleum expert 7.0 software with MBAL version 10.0 (2009) with Microsoft office. Production profile from the field commenced in the year 1998.. From the decline curve analysis it is observed that the decline curve type is the hyperbolic with the smallest standard deviation 7.45stb/day). (See appendix for the decline plots)

Year	t	Annual stb/day	Annual production (MMSTB)	Cumulative production
1998	0	0	0	0
1999	1	820.00	0.299	0.299
2000	2	796.18	0.0291	0.590
2001	3	645.42	0.235	0.825
2002	4	530.65	0.1936	1,019
2003	5	442.98	0.6168	1.181
2004	6	376.45	0.1374	1.38
2005	7	325.79	0.1891	1,437
2006	8	287.21	0.1048	1.542
2007	9	257.75	0.0908	1.636
2008	10	235.39	0.0859	1.722
2009	11	218.37	0.0797	1.802
2010	12	205.40	0.0749	1.877
2011	13	198	0.0722	1.949
2012	14	185	0.0675	2.016
2013	15	174	0.0635	2.080

Table 2: Production forecast of the field X

Table 2 show the result gotten from the production forecast from the hyperbolic decline rates (see appendix) of the fields from the first year till it is uneconomical to produce from that fields.

Parameters	Values	Sources
Initial investment CAPEX (cost of work over on the well or redevelopment cost)	$ 15.0M	NNPC/NAPIMS (2015)
Sustainable corporate social development levy	1%	NNPC/NAPIMS (2015)
Educational trust fund (ETF)	2%	Survey
Price inflation (assumed)	2.0%	Iledare (2009)
Price of oil	$55bbl (MOD)	Cable Network News CNN
Royalty rate (sliding scale)	5%	Wood Mackenze report 2002
Petroleum profit tax (for marginal fields)	55%	Wood Makenze report (2002)
Cost inflation	18%	CBN report 2017
Discount rate	14%	(Current monetary policy rate MPR)
OPEX (direct cost of producing the well)	6$/bbl	Survey
NDDC tax	3%	Survey
Depreciation	5yrs SLD	20@ straight line capital allowance for investment in capital allowance
Project life	15yrs	Production profile
Initial production rate	820STB/day	Field history
Recovery	2.08MMSTB	Production profile

Table 3: Summary of data used for cash flow model

Economic evaluation:

Economic evaluation was carried out on field X operated by ZACO to know if this recovery will be profitable to the investor. The following data were used during the economic evaluation. Table 3 shows the economic parameters for the model are CAPEX, OPEX, Price inflation rate, Cost inflation rate, Discount rate, Price of oil, Royalty rate and Tax, while the engineering parameters include, Production rate and Ultimate recovery.The deterministic and probabilistic model is given intable 3B.

	Initial Inv	15	$M		Price of oil	55	$/bbl		Cost inflation	18	%		Discount Rate	14	%		
	Initial pro	820	bbl/d		Price inflati	2	%		Variable Opex	6	$/bbl		NDDC	3	%		
	ETF	2	%		Royal rate	5	%		Fixed Opex	5	% of Capex		Depreciation Life	5	SLD		
	SCDL	1	%		PPT	55	%		Prod. Days	365			Project Life	15	Years		

YEAR	t (years)	CAPEX	Annual Rate STB/DAY	Annual Production MMBBL	Cumm. Production MMBBL	Oil Price ($/bbl)	Gross Revenue ($M)	Royalty ($M)	OPEX ($M)	Depreciation ($M)	Net Revenue ($M)	Tax ($M)	Cash in ($)	Cash out ($)	NCF ($M)	Cumm. NCF ($M)	PV NCF @ 14% ($M)
2014	0	15	0	0	0	0	0	0		0	0	0	0	15	-15	-15	-15
2015	1	0	820	0.299	0.299	55	16.462	0.823	1.738	3	12.638	7.709	7.929	1.738	6.191	-8.809	5.799
2016	2	0	796.177	0.291	0.590	54	15.664	0.783	1.859	3	11.880	7.247	7.633	1.859	5.774	-3.034	4.744
2017	3		645.42	0.236	0.825	53	12.444	0.622	1.790	3	8.822	5.381	6.440	1.790	4.651	1.616	3.352
2018	4		530.615	0.194	1.019	52	10.026	0.501	1.738	3	6.524	3.980	5.545	1.738	3.806	5.423	2.406
2019	5		442.779	0.162	1.181	51	8.199	0.410	1.704	3	4.789	2.921	4.868	1.704	3.164	8.587	1.754
2020	6		376.45	0.137	1.318	50	6.831	0.342	1.688		6.490	3.959	2.531	1.688	0.843	9.430	0.410
2021	7		325.787	0.119	1.437	49	5.794	0.290	1.688		5.504	3.357	2.147	1.688	0.458	9.888	0.195
2022	8		287.205	0.105	1.542	48	5.005	0.250	1.707		4.755	2.901	1.854	1.707	0.148	10.036	0.055
2023	9		257.754	0.094	1.636	47	4.402	0.220	1.743		4.182	2.551	1.631	1.743	-0.112	9.924	-0.037
2024	10		235.396	0.086	1.722	46	3.940	0.197	1.799		3.743	2.283	1.460	1.799	-0.339	9.585	-0.098
2025	11		218.37	0.080	1.802	45	3.582	0.179	1.875		3.403	2.076	1.327	1.875	-0.548	9.037	-0.138
2026	12		205.404	0.075	1.877	44	3.302	0.165	1.974		3.137	1.913	1.223	1.974	-0.750	8.287	-0.166
2027	13		198	0.072	1.949	43	3.119	0.156	2.114		2.963	1.808	1.156	2.114	-0.958	7.329	-0.186
2028	14		185	0.068	2.016	42	2.856	0.143	2.224		2.713	1.655	1.058	2.224	-1.165	6.164	-0.199
2029	15		174	0.064	2.080	41	2.633	0.132	2.353		2.501	1.526	0.975	2.353	-1.377	4.786	-0.206

Profitability Indicators	Values	Unit
NPV @ 14%	2.7	$M
IRR	20%	
PI	1.2	
Payout Period	2.49	Years
PVR	0.2	

Table 3B: The cash flow model (deterministic and probabilistic)

Statistics/Percentiles	NPV ($M)	IRR (%)	PI	PVR	PBP (Yrs)
Trials	10,000	10,000	10,000	10000	10,000
Base Case	2.7	20	1.2	0.2	2.49
Mean	7.1	41	1.7	0.7	1.73
Variance	2.0	0.0	0.0	0.0	0.02
P_{90}	5.3	34	1.5	0.5	1.56
P_{50}	7.1	41	1.7	0.7	1.72
P_{10}	9.0	47	1.9	0.9	1.89
Certainty Level/Range	70.3 5.8 <NPV<8.6	70.00% 37< IRR <48	70.45% 1.6<PI<1.9	70.94% 0.5<PVR<0.9	75.13% 1.62< PBP<2.04

Table 4: The Simulation Statistics for the Forecast

RESULTS AND DICUSSION

Discussion of result of the Cash Flow Model:

From table 4 the analysis registered a positive Net Present Value of $2.7Million at a 14% discount rate which is positive and economically viable being an independent project. Besides, the Internal Rate of Return (IRR) is 20% also higher than the hurdle rate and thus reduces the impact of inflation. Furthermore, the Profitability Index (PI) that measures the present value benefits per capital invested also recorded a value of 1.2 which is slightly higher or greater than one. Finally, a better Payout Period of 2.49 years was gotten from this showing that cash flows will be generated at early stage of the investment. From the above, even if the NPV gotten from the analysis may be unattractive in the short run. There is highoptimism that there will be favourable variation in the input parameters like oil price, cost inflation, tax, etc, in the long run that will yield higher profitability. Finally, understanding and quantifying the inherent risk of this project effectively may also enhance the confidence level of profit making. Some of the assumption an input data into the excel spread sheet are given in table 2.

Probabilistic Analysis (Monte Carlo Simulation):

Risk analysis was also carried out on the profitability indicators to handle the uncertainties in the input variable of the economic model. Sensitivity analysis was also performed to identify the key parameters that have direct impact on profitability of the venture.The risk analysis was carried out to identify and quantify the inherent risk initiated by the input parameters in the single value deterministic model on the output value (NPV, IRR etc.). This was done in other to determine the chances that the risk will occur and the cost if it does with a view of guiding the investor to decide whether a risk is worth taking or not. To achieve this, a probabilistic evaluation involving stochastic assessment of the deterministic single value (NPV,IRR, PI, andPBP) was carried out through Monte Carlo Simulation process using Oracle Crystal Ball Software. The identified uncertain variables used are initial investment, variable OPEX, fixed OPEX, tax rate (PPT), cost inflation and oil price. Triangular probability distribution was used for all the assumption since it has a maximum, most likely and minimum values.

The simulation was run for 10,000 trials in order to increase the accuracy of the measurement with the base case of the NPV, IRR, PI and PBP for the project and the probability was computed as the probability that it is above that value. The NPV, IRR, PI of the project followed a Beta distribution while PBP followed a gamma distribution.

Discussion of Stochastic Result:

The results of the simulation statistics given in Table 4 , show that the probability that the Net

Present Value (NPV) will be above $5.3 Million is 90% which is represented as P_{90} and the probability that NPV will be above $9.0 Million is 10% represented as P_{10}. The 50% chance of the NPV is $7.1 Million which is the most suitable for investment. The Frequency Curve for NPVin Fig.1 shows a certainty level of 70.3% occurring at a certainty range of $5.8 Million and $8.5 Million coloured as blue. This value informs the investor (operator) that there is 70.3% confidence level that the NPV of the project will lie between $65.8 Million and $8.6 Million which also captures the P_{50} (Median value). Similarly, the Internal Rate of Return (IRR) gave P_{90}, P_{50}, and P_{10} values as 34%, 41% and 47% respectively which are all above the hurdle rate used for this study. The IRR Frequency Curve in Figure 2 showed 70.00% confidence level of having the IRR falls between 37% and 48%. The profitability Index (PI) proved that there is 90% chance of getting a PI above 1.5. However there is 50% chance of PI will be 1.7 and 10% chance that PI will be greater than 1.9.

There is also 70.45% probability of having PI falling between 1.6 and 1.9, refer to Figure 3. Finally, is the Payout Period (PBP) which is a key indicator for the investor as it informs him of the time the investment will breakeven. It was observed that there is 10% probability that the project will pay out above 1.89 years while the probability for PBP above 1.56 years is 90%. A certainty level of 75.13% was gotten for the payout period to lie between 1.62 years and 2.04years. The frequency curve for the payout period is given in Figure 4. In all of these evaluations, it was observed that certainty levels are higher than the P_{50} values which reduces the uncertainties in the investment. The probabilistic evaluations serve as perfect information guiding the investor's decision making process with a view of overcoming the inherent risk in the venture.

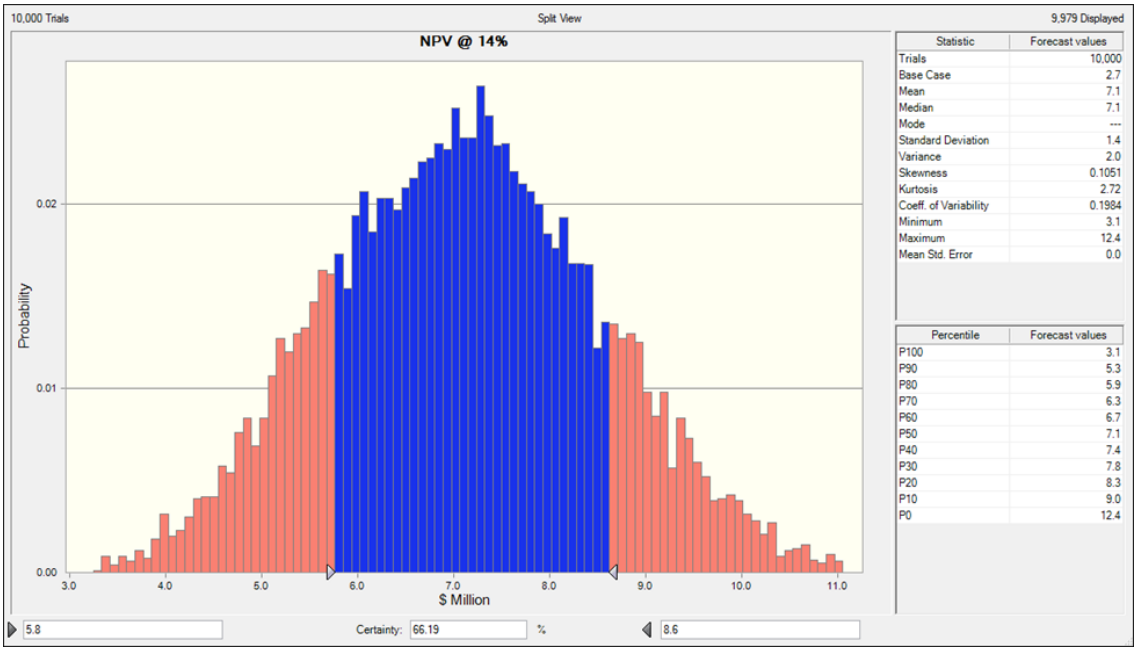

Figure 1: Frequency Curve for NPV

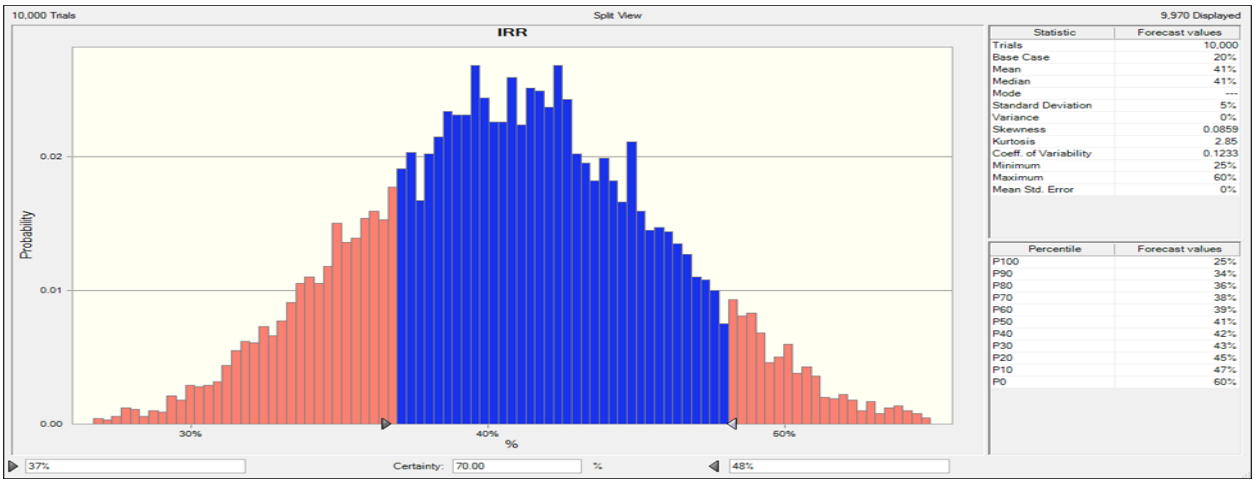

Figure 2: Frequency Curve for IRR

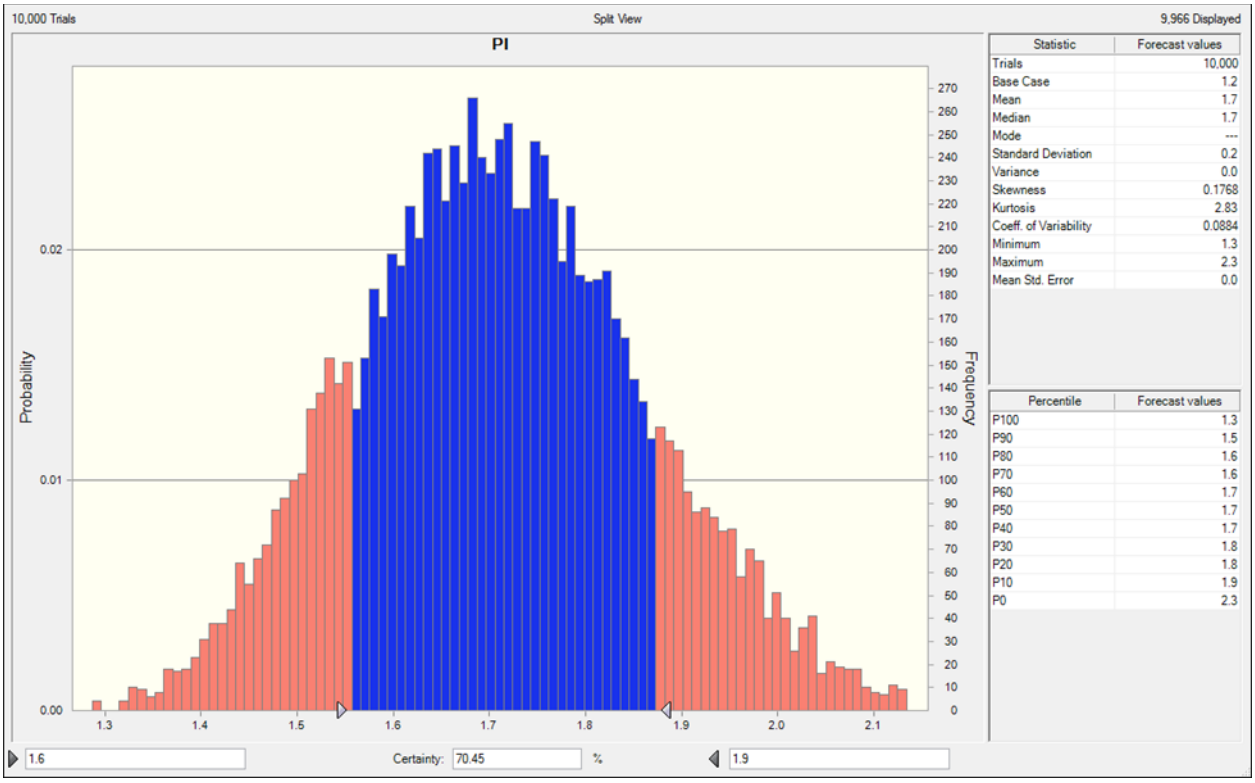

Figure 3: Frequency Curve for PI

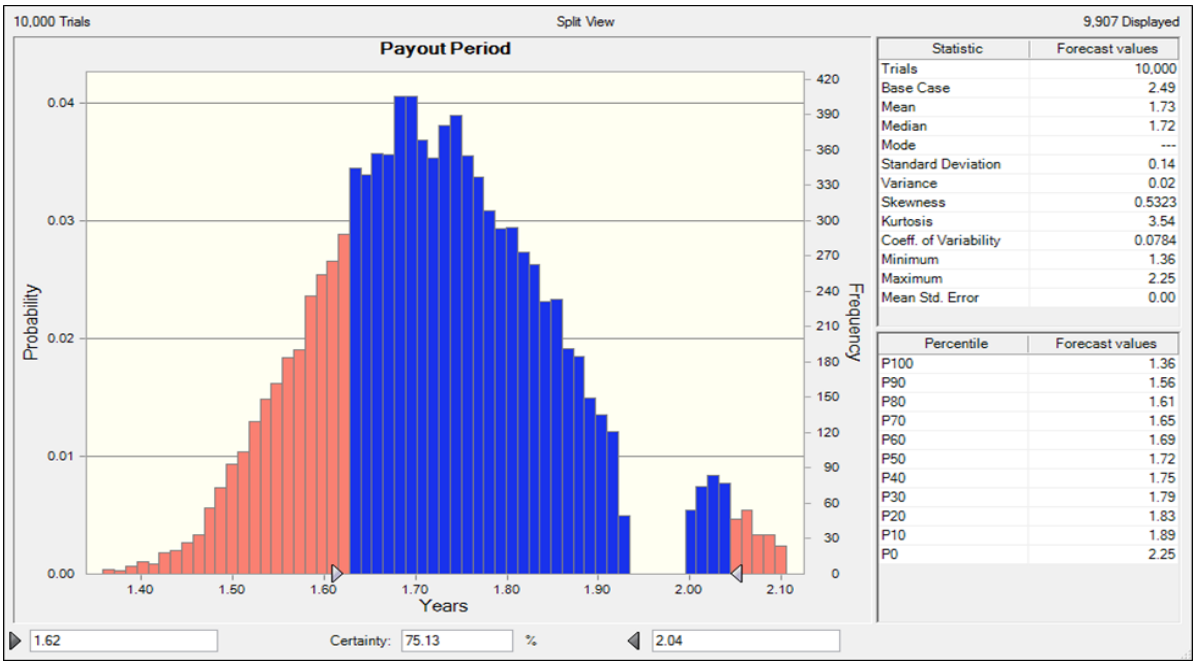

Figure 4: Frequency Curve for PBP

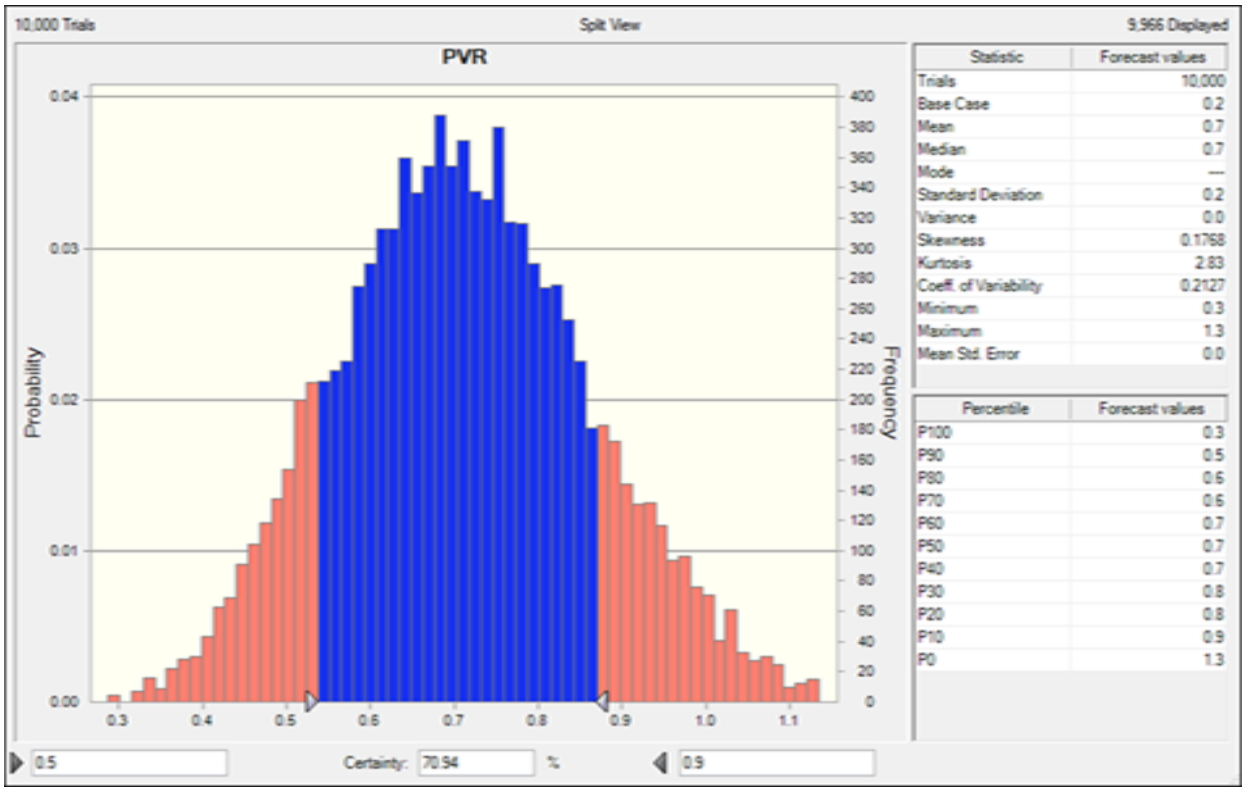

Figure 5: Frequency curve for PVR

Sensitivity Analysis of Profitability Indicators:

Figure 6 to 7 show the sensitivity analysis on NPV, IRR and Payback. It shows the various effects of changes in the values of oil price, tax rate, Capex and Opex. It was equally observed that the sensitivity analysis of profitability index, profit to investment ratio and present value rate follow the same trend with IRR. This would aid decision making as the oil price and tax rate were discovered to be the most sensitive parameter whose slight changes will affect profit earning of any investor. For instances as shown in fig the oil price will affect IRR by 20.5%, NPV by 19.6% and payback period by 23.6%. It is also clear from these figures that, increase in the value of oil price reduces payback period while it increases the value of NPV and IRR.

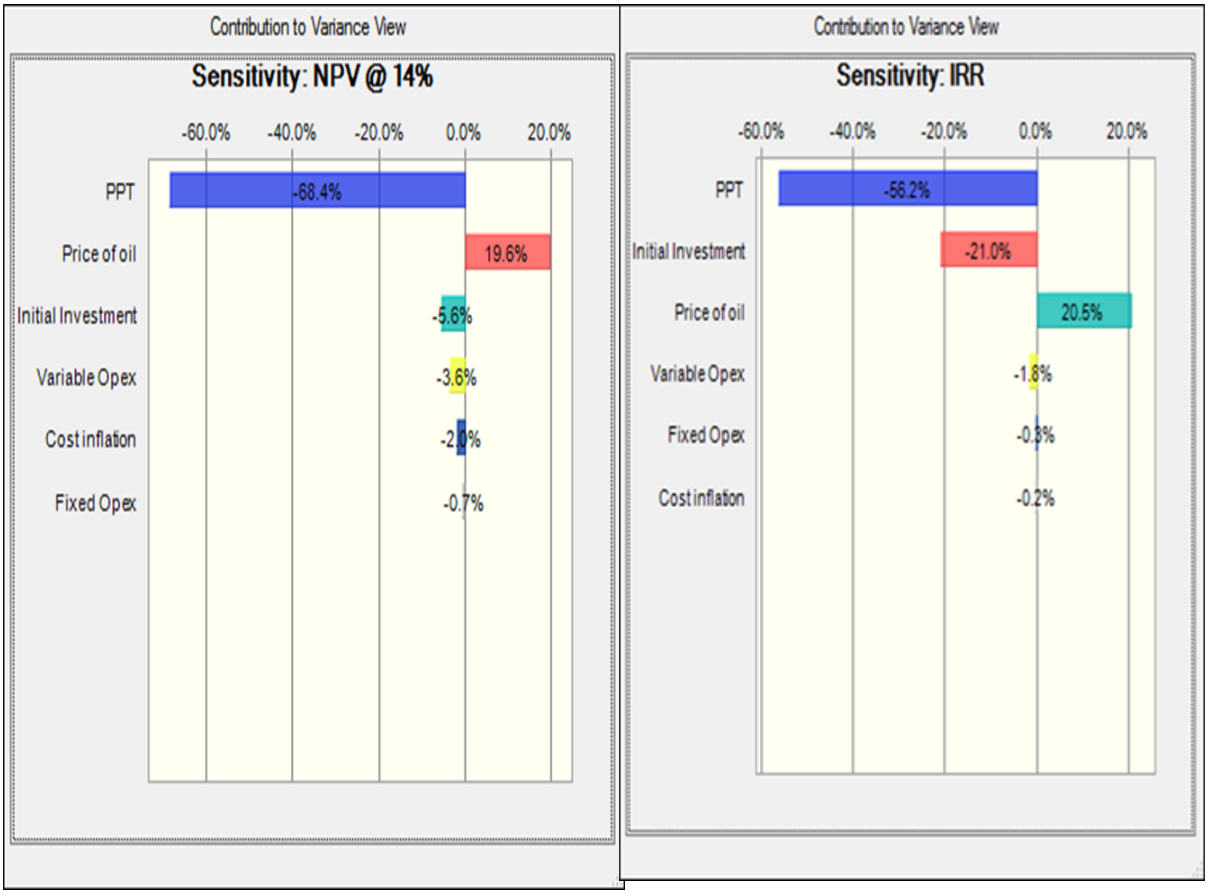

Figure 6: NPV and IRR sensitivity chart

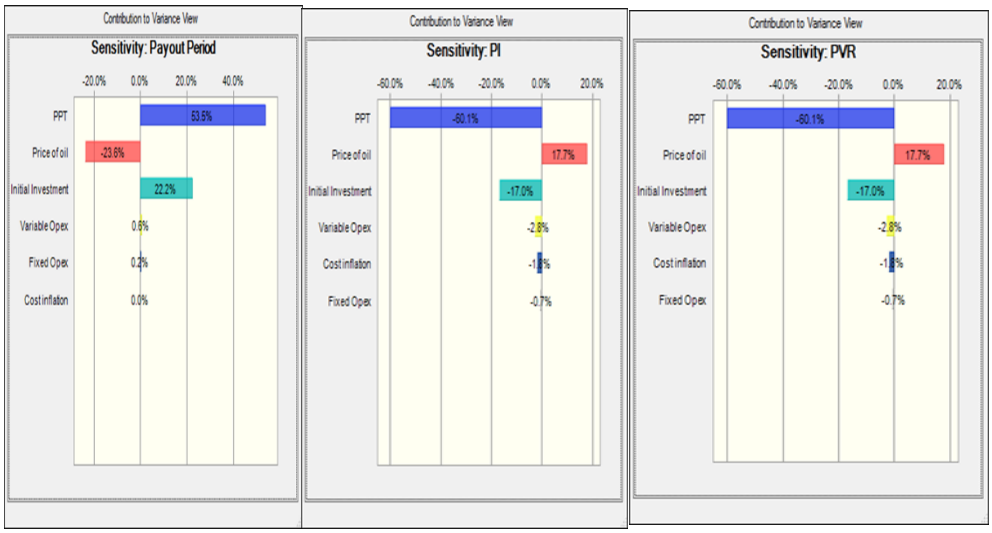

Figure 7: PBP, PI and PVR sensitivity charts

The Tonardo and spider chart:

The sensitivity analysis was carried out for all the profitability indicators that is NPV, IRR, PI, PVR and Payout period using Spider Charts and Tornado Diagram in Oracle Crystal Ball software. From the sensitivity analysis carried out, the sensitivity from highest to lowest for the NPV are tax, oil price, initial investment (CAPEX), variable OPEX , fixed OPEX and cost inflation refer to the Tornado charts. Tornado chart are used to measure the effect of the changes in any given variables on a selected forecast (NPV), this was done deterministically using the crystal ball software while the sensitivity analysis was done probabilistically.

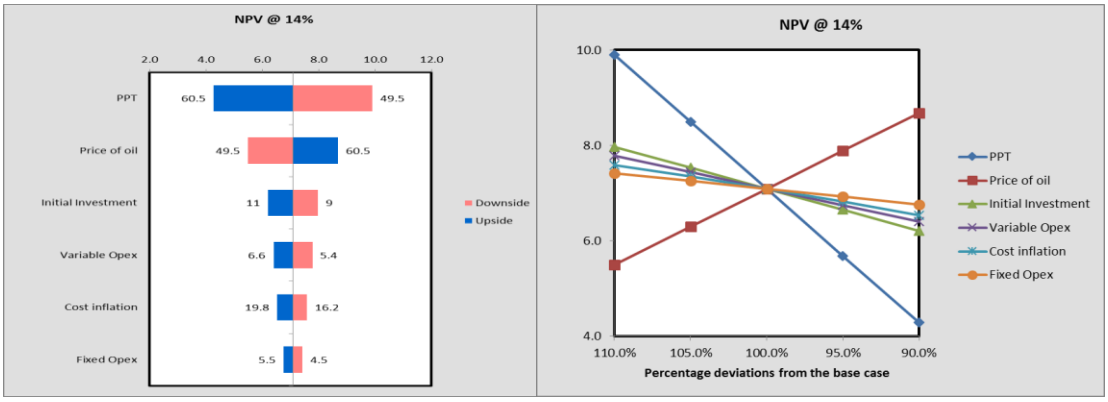

Figure 8: Tornado and Spider chart for NPV

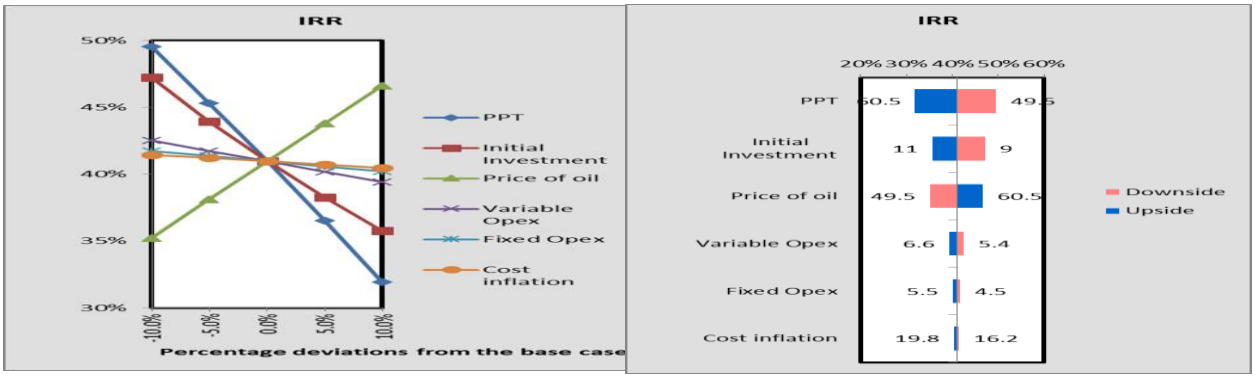

Figure 9: Tornado and spider chart for IRR

The Spider Chart in Fig 8 shows that increase in the price of oil will increase the NPV positively by increasing the value while same increase in tax, initial investment, OPEX and cost inflation reduce the NPV of the venture.

The Tornado chart for the IRR model in Fig.9 showed tax rate, initial investment, oil price, OPEX and cost inflation having impact on the IRR in decreasing order. The Spider diagram in Fig 9 showed how the variation of each parameter affects the IRR. It was seen that increasing the Oil Price of the product affects the IRR positively by increasing its value above the hurdle rate. However, increase in the value of Tax rate, initial investment, OPEX and cost inflation decreases the IRR of the project. The sensitivity analysis of the other profitability indicators like Profitability Index (PI), and the Payback Period (PBP) also followed the same trend as the IRR. (Not shown)

Sensitivity Ranking:

Table 11: Sensitivity ranking

	Oil Price	**Tax Rate**	**Initial Investment**	**Variable Opex**	**Fixed Opex**	**Cost Inflation**
NPV	2	1	3	3	4	5
IRR	3	1	2	2	4	5
PI/PVR	3	1	2	2	4	5
PBP	2	1	3	2	4	5
	Key: The ranking decreasing from 1 to 5					
Source: author's Computation						

Table 5: Sensitivity Ranking

Table 5 shows the sensitivity table for the various indicators.

The ranking of sensitivities of the input variables (assumptions) on the profitability indicators

(forecast) was carried out to determine the order in which the variables influence the profit indicators of the project. From table 7 it can be deduced that, tax rate and oil price have the highest influence on the Net Present Value and the Payback Period. The implication is that, for the project to have a higher NPV and a shorter breakeven point, then the price of oil must increase above the base case while the Petroleum Profit Tax payable to government reduces. In a similar manner, it was seen that the Internal Rate of Return (IRR), Profitability Index (PI) and payout period are rather influenced mainly by the initial investment and the tax rate. This means while the tax paid to the state is reduced, the investor will also spend less on the project to generate cash flow at early stage of the project thereby increasing rate of return and return on dollar invested. Although Marginal Field Fiscal Policy that uses (production sharing contract) PSC based on R-Factor usually encourages higher spending by contractors on marginal field project to attract higher net profit. In practice this policy is still not appreciated by the investors considering the impact of increased spending.

Tax rate is the most sensitive parameter, however, Cost Inflation became the variable with the least influence on all the profit indicators and that implies that variation in inflation rate may not significantly affect the profitability of the venture.

CONCLUSION AND RECOMMENDATIONS

The results obtained from the deterministic model of this study are very impressive with NPV of 2.7 million and IRR of 20%. Probabilistically, the certainty of having a positive net present value (NPV) and good IRR values were obtained and these clearly show the profitability of developing onshore marginal fields in Nigeria.

The sensitivity analysis outlined oil price and tax rate as key sensitivity parameters in maximizing profit. Therefore, the probabilistic approach has aided in forecasting the impact of the uncertainty associated with the variable parameters and gave ranges of all possible profits and losses that would be encountered. From the economic indicators in the results and discussion, we can conclude that the development of onshore marginal oil fields is economically viable.

It is recommended that to aid marginal field development in Nigeria the government should reduce the fiscal frame like the royalty paid by the operators to enhance profitability. Special tax incentives should be given to marginal field operators such as reduced tax and .capital allowance. Also commercial bank should give loan to the operators at a reduced interest rate and finally government should provide enabling environment to make easy assessment of funds by creating energy financing banks.

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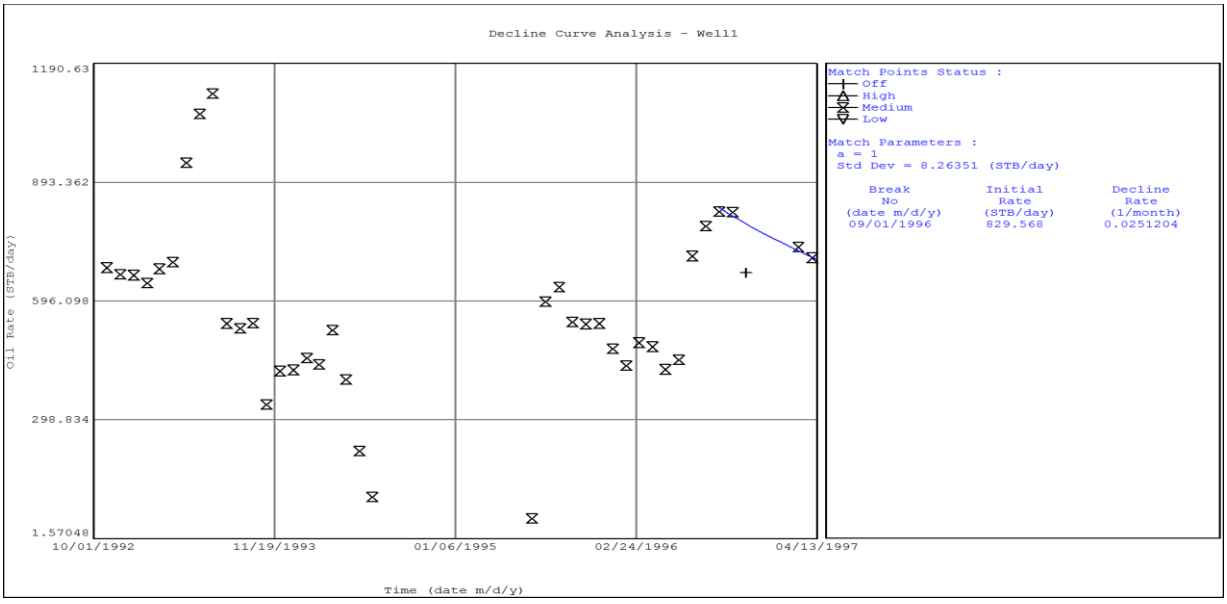
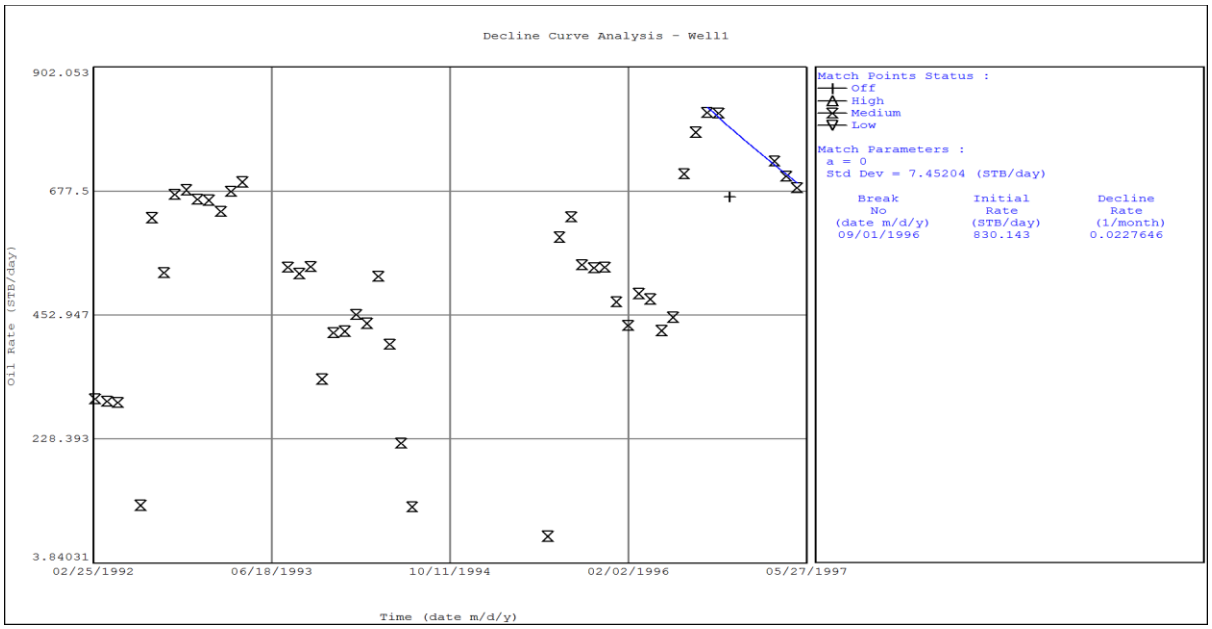
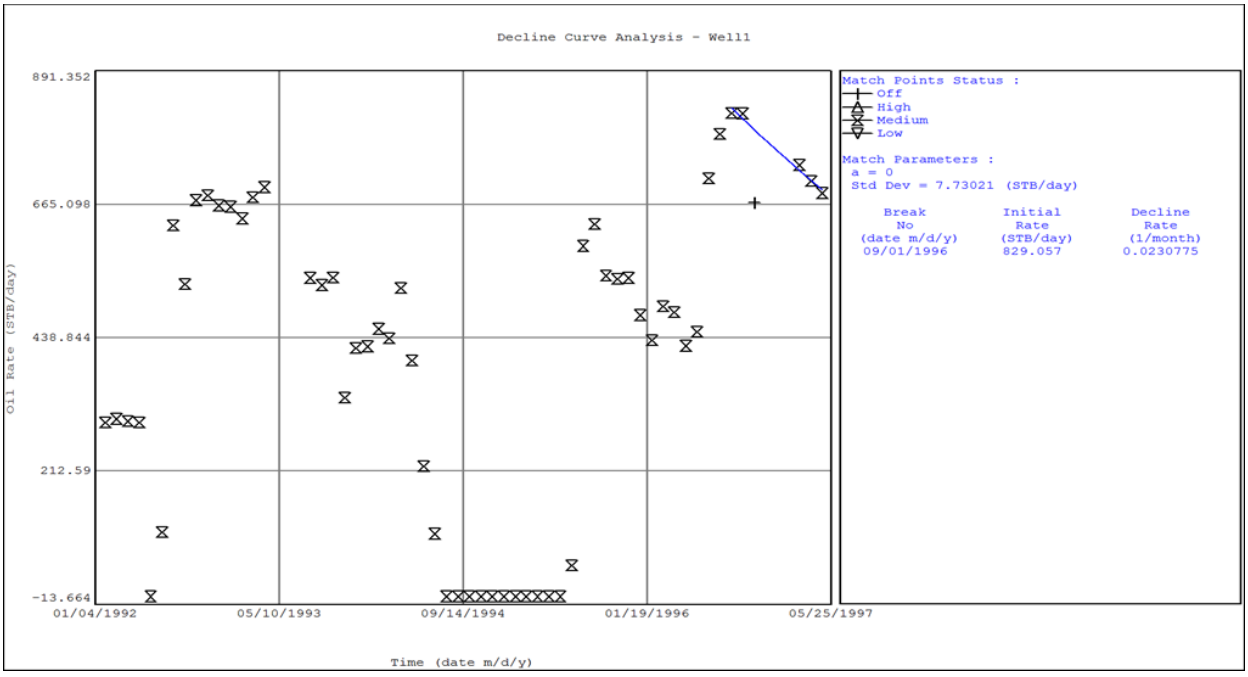
APPENDIXES: The decline Curve analysis plots



A. The Harmonic decline plot



B. The hyperbolic decline plot



C. The Exponential Decline Plot