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Evaluation of Production Sharing Contract (Amendment) Act 2019 and Petroleum Industry Act 2021 using Deterministic and Stochastic Model

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Abstract:
The revenue of Nigeria Government comes majorly from oil and gas operations that are carried out through international and indigenous oil companies. This revenue is generated through fiscal instruments which are designated as taxes, royalty, profit oil, rentals. Crypto levies like Niger Delta Development Agency levy and education tax etc, also apply. The federal government has always sort out ways to derive more from the oil and gas activities since its inception. This they have pursued through legislative reforms, amongst which are the Deep Offshore and Inland Basin Production Sharing Contract (amended) act 2019, and the most current one which is the Petroleum Industry Act (PIA, 2021). The 2021 PIA has a significant difference from previous fiscal legislative acts as the Petroleum Profit Tax (PPT) has been splitted into Corporate Income Tax (CIT) and Nigeria Hydrocarbon Tax (NHT). In this research work we applied the deterministic spreadsheet to a Nigeria deep water asset to access the impact of the Production Sharing Contract (amended) act 2019 and Petroleum Industry Act 2021 regimes. The uncertainties and risks associated with the venture were analyzed with the results from the deterministic model by a simulation tool @Risk, a Monte Carlo simulation tool. The 2021 PIA gave a Net Present Value (NPV) of 595.18 MM$ which is positive and above opportunity cost of capital, Internal Rate of Return (IRR) of 23.7%, a Profitability Index (PI) of 1.34, the Host Government take of 88.1%, and Contractor take of 11.9%. The investment under the fiscal regime of 2021 PIA gave positive values of profitability indicators which gave higher profits than that of the Production Sharing Contract (amended) act 2019 that generated government take of 82.2%.

Keywords: Deep Offshore and Inland Basin Production Sharing Contract (amended) act 2019, Petroleum Industry Act 2021, Monte Carlo simulation, Internal rate of Return (IRR), Petroleum fiscal regime, Net Present Value, Government Take.

I. INTRODUCTION
The global demand for energy consumption continues to rise daily, necessitating persistent exploration and production of fossil fuels. The oil and gas industry remains the primary sector responsible for meeting these expanding energy needs due to its high efficiency in energy conversion compared to existing alternatives. In developing petroleum fiscal systems, nations prioritize a stable business environment that minimizes foreign risk, discourages speculation, and balances risk and reward for both the state and international oil companies [9].

In Nigeria, the government has mandated the Nigerian National Petroleum Corporation (NNPC) Ltd to establish institutions with clearly defined roles, fostering a commercially oriented and profit-driven national petroleum company. This initiative aims to enhance transparency, good governance, and accountability while deepening local content practices [36]. The passage of the Petroleum Industry Act (PIA) 2021 introduced a progressive fiscal regulation designed to boost investment interests and increase federal government revenue through a simplified petroleum tax administration [36].

Historically, the Nigerian economy shifted its focus toward petroleum in the late 1950s, with oil subsequently becoming the primary source of government income, accounting for over 90% of total exports and 80% of aggregate revenue [31]. According to the Organization of Petroleum Exporting Countries (OPEC), the oil and gas industry contributes approximately 30% to Nigeria's Gross Domestic Product (GDP) [33]. The sector is recognized as the most critical in the country, providing adaptable

energy for a wide variety of needs [8, 5,]. Beyond revenue generation, the oil industry facilitates national development through employment opportunities, industrialization, and income generation [28].

International Oil Companies (IOCs) operate within a petroleum fiscal system a framework describing the contractual relationship and taxation structure between the government and investors [24]. Taxation serves as the foundational revenue source for modern governments, often accounting for over 90% of their income [1]. The Petroleum Profit Tax Act (PPTA) of 1959 previously oversaw industry taxation, with a standard tax rate of 85% for taxable income, reduced to 65.75% for initial operational years, and 50% for production sharing contracts [32] The Petroleum Industry Act (PIA) 2021 introduces a transformative fiscal regime, including the Nigerian Hydrocarbon Tax, Royalties, and Companies Income Tax, aimed at balancing the takes of the government and investing contractors. This research specifically compares the PSC (Amendment) Act 2019 and the PIA 2021 to evaluate their impact on Nigerian deep-water assets.

The Nigerian government has historically sought to maximize economic rent from oil production to fund national budgets [4]. Recent legislative changes, including the PSC Act 2019 and the PIA 2021, introduced a dual tax structure by splitting the Petroleum Profit Tax (PPT) into Corporate Income Tax (CIT) and Nigeria Hydrocarbon Tax (NHT). There is a critical need to evaluate how these fiscal reforms affect the cash flow and "take" statistics for the Nigerian government compared to previous regimes.

The primary aim of this study is to critically evaluate the impact of the Production Sharing Contract (Amendment) Act 2019 and the PIA 2021 on the Nigerian government and investors using deterministic and stochastic methods. The specific objectives include developing cash flow models based on the fiscal provisions of the 2019 PSC Act and 2021 PIA, applying deterministic analysis to project economics under both regimes, utilizing profitability indicators to analyze the fiscal systems, and incorporating stochastic simulation to assess risks and uncertainties.

This study covers the economic evaluation of deep-water assets under the PSC Act 2019 and PIA 2021 using deterministic and Monte Carlo simulations. The findings will provide strategic guidance for policy makers and investors to maximize economic rent and ensure sustainable returns on investment. Ultimately, the study will aid stakeholders in the upstream petroleum industry in evaluating complex investments, balancing fiscal reforms with sustainable development goals.

The search for oil in Nigeria began in the early 20th century with the Nigerian Bitumen Corporation in the Araromi area (NNPC, 2005). Exploration resumed in 1937 when Shell-BP entered the scene, leading to the discovery of the first commercial oil well at Oloibiri in 1956 [31]. Following this milestone, rights were extended to other major companies such as Mobil, Gulf (now Chevron), and Agip, though Shell remained the dominant producer [32]. Nigeria's production capacity grew significantly from 5,100 barrels per day (bpd) to an average of 2.7 million bpd (NNPC, 2018). The establishment of the Nigerian National Petroleum Corporation [26] in 1977 marked a shift toward state control and participation in the oil industry (Onyemaechi, 2012). Structurally, the industry is divided into three major sectors: upstream (exploration and production), midstream (transportation and processing), and downstream (refining and distribution) [23]. Supporting these operations is the oilfield services sector, which provides essential technology and expertise.

Early oil policies during the colonial era, such as the Petroleum Ordinance of 1889 and the Oil Ordinance of 1907, were designed to favor British subjects and companies, thereby discouraging non-British investors [29]. The Mineral Oils Ordinance of 1914 granted Shell D'Arcy a near-monopoly over exploration rights. Later, rights were categorized into Oil Exploration Licenses (OEL), Oil Prospecting Licenses (OPL), and Oil Mining Licenses (OML), each with specific durations and requirements [29]. Nigeria's independence in 1960 ushered in new legislation, most notably the Petroleum Act of 1969, which remains a foundational law vesting ownership of all mineral resources in the Federal Government (CFRN, 1999; Petroleum Act, 1969). The Act empowered the Petroleum Minister to grant licenses for exploration and production. Subsequent reforms included the Nigerian Associated Gas Reinjection Act of 1979 and the Production Sharing Contract Act of 1993. The oil price crash of 1986 led to the introduction of the Memorandum of Understanding (MOU), which provided fiscal incentives to sustain operations [29].

The Petroleum Profits Tax Act (PPTA) regulates the financial activities of oil companies. Petroleum

operations encompass the mining, obtaining, and transportation of chargeable oil (PPTA Section 2). Traditionally, the tax rate was 85% of chargeable profits, with variations for new operations and production sharing contract [32]. Profit determination involves calculating adjusted, assessable, and chargeable profits after deducting allowable costs and losses [32].

A comparative analysis of non-OPEC countries such as Norway, the UK, and the US reveals several critical lessons for Nigeria. Diversified revenue streams are essential, as successful nations emphasize non-oil sectors to reduce vulnerability to price shocks [22]. Stabilization funds, such as Norway's Government Pension Fund Global, serve as models for saving surplus revenue [27]. Transparency and predictable fiscal terms attract long-term investment, while flexibility in fiscal regimes allows governments to adjust based on oil prices, protecting investors during downturns while capturing revenue during booms.

Despite significant reforms such as the PSC (Amendment) Act of 2019 and the PIA 2021, there remains limited empirical evidence evaluating their combined effect on project economics and government take. Existing literature lacks integrated fiscal evaluations using stochastic frameworks tailored to Nigerian deep-water assets. This research addresses this gap by analyzing the trade-offs between government revenue and investor incentives under these new legislative frameworks, thereby contributing to a more comprehensive understanding of Nigeria's evolving petroleum fiscal system.

Table 1: PIA 2021 and PSC 2019 (Adapted from : PIA 2021 Gazette and PSC Act 2019)

Topic	PIA 2021	DOIBPSC Amendment Act (2019)
Purpose & scope	Nationwide overhaul: legal/ governance/ regulatory/ fiscal for upstream, midstream, downstream; creates new institutions and fiscal rules.	Targeted amendment: changes specific to deep offshore & inland basin PSCs (1999 Act framework) — fiscal and contractual tweaks for ongoing PSCs.
Ownership / title to petroleum	Confirms State ownership and vests control in the State — provides clearer title and licensing framework.	Works within State ownership concept but reforms revenue sharing/entitlement mechanics for contractors under PSCs (no change to State ownership).
Regulatory institutions	Establishes Nigeria Upstream Petroleum Regulatory Commission (NUPRC) and Nigeria Midstream & Downstream Petroleum Regulatory Authority (NMDPRA) and clarifies NNPC's commercial role. Restructures approvals & permits.	Leaves regulator/agency structure in place for PSCs; focuses on contractual terms rather than creating new national regulator architecture.
Fiscal regime — taxes	Introduces a new hydrocarbon tax and other new fiscal instruments (replaces/augments previous PPT regime for many upstream activities), plus company income tax carve-outs/exceptions; deep offshore exceptions exist. This is a fundamental fiscal shift.	PSC 2019 primarily adjusted royalties & some PSC fiscal mechanics; it did not create the PIA's broad new tax regime. It changed how royalties on deep offshore are calculated (introducing combined production/price basis).
Royalties	PIA preserves royalty concepts but sits within the new fiscal/tax mix; it also introduced modernized royalty & rent considerations through regulation. (Detailed royalty schedules are regulated).	Key change: introduced a combined production-and-price based royalty replacing older production-only royalties for deep offshore/inland basin fields; also set baseline royalties and review mechanisms.
Host communities & social obligations	PIA explicitly establishes a Host Communities Fund and places obligations on operators and the NNPC/companies for development and remediation.	The 2019 PSC amendment did not create a nation-wide host-community fund like the PIA; community obligations remained contractually driven under PSCs and other laws.
Penalties & enforcement	PIA strengthened regulatory enforcement powers and sanctions across the industry.	PSC 2019 introduced minimum fines (e.g., very large fines) for non-compliance with PSC obligations and criminal penalties for certain breaches.

II. Materials and Method

3.1 MATERIALS

The materials that would be used in this work are Deep Offshore and Inland Basin Production Sharing Contract Amendment Act 2019, Petroleum Industry Act 2021. Deterministic MS Excel, Monte Carlo simulation software (@Risk) would be used for evaluation.

3.2 METHODS

Using an excel spreadsheet after the pattern presented by (Mian) and (iledare,2019), an economic model was built, and all economic indicators

analyzed. The process is made up of the various steep of inputting the data for modeling in the various equation representative of the process.

- Annual production forecast is carried out reflective of the life of the field through the process of production forecasting. The oil price is projected and subsequently the gross revenue was computed.
- Special treatment of the Cost outlay reflective of the technical cost.
- Computation of the split of oil profit as the government and contractors take were subject to discounted and undiscounted treatment of their take statistics.
- Computation of Profitability Indicators.
- The results obtain from this research that are deterministic are then treated to ascertain the risk and uncertainty inherent in them.
- The extent to which input parameter such as discount rate, oil price, etc., would affect profitability was then carried out on this venture through sensitivity analysis.

3.2.1 Forecast of volume of oil produced

In this work, the exponential technique was used. Three techniques are shown in Table 2.

Table 2: The Arp's Equations (Adapted from: Chukwuemeka, 2011)

	Exponential	Hyperbolic	Harmonic
Decline Rate, (a_i)	$\frac{q_i - q_t}{N_p}$	$\frac{\left(\frac{q_i}{q_t}\right)^b - 1}{bt} = \left\{\frac{q_i}{N_p(1-b)}\right\}\left\{1-\left[\left(\frac{q_i}{q_t}\right)^{1-b}\right]\right\}$	$\frac{q_i}{N_p}\ln\frac{q_i}{q_t}$
Prod. Rate, (q_t)	$q_i \exp(-a_i t)$	$\frac{q_i}{\{1+ba_it\}^{1/b}}$	$\frac{q_i}{\{1+a_it\}}$
Cum. Prod. (N_p)	$\frac{q_i - q_t}{a_i}$	$\left\{\frac{q_i}{a_i(1-b)}\right\}\left\{1-\left[\left(\frac{q_i}{q_t}\right)^{1-b}\right]\right\}$	$\frac{q_i}{a_i}\ln\frac{q_i}{q_t}$

a_i = represents the nominal decline rate per unit time.
q_i = represent the initial production rate bopd
q_t = represents production rate at time t, bopd.
b = this represent the hyperbolic exponent. Computed through the Newton Ralphson's Iterations (Ahmed, 2000)
t = represent time in days, months or years: in using this there must be uniformity units
N_p = represents the cumulative production in bbls.

The annual and the cumulative production values are computed with Arp's equation. In the Plateau phase, the rate of production throughout is constant. *The Cumulative production,* $N_p = q_p t$

The Annual production, $N_a = q_p t$

The decline phase is usually the economic limit of the field. The cumulative production, annual production rate decline rate and production rate are the variables used in this research.

The Decline rate, $a_i = \frac{q_p - q_{el}}{N_p}$ -

3.2.2 Mechanism of pricing and revenue

The price of oil is expressed in both nominal and real terms as shown;

$$Price\ Index = \frac{Nominal\ Price}{Real\ Price} x\,100\%$$

In this research work the price of a barrel of Brent Crude use is the nominal price considered to be 55US$/stb and a CPI value of 2% use to Model the period the project is considered viable as in the life of the project. The gross revenue is given as;

Annual Gross Revenue (GR)= Annual production x Oil price

3.2.3 Nigerian fiscal instruments

Fiscal instruments comparison as specified in PSC 2019 and PIA 2021 are shown in table 3.

Table 3: Fiscal Properties Comparison: PSC 2019 vs PIA 2021 (Deep Offshore)

Fiscal Element	PSC 2019	PIA 2021
Royalty (production-based / terrain)	Flat 10% on chargeable volume of crude & condensate for deep offshore (>200m)	5% ≤50,000 bpd; 7.5% >50,000 bpd
Price-based (Windfall) Royalty	0% up to $20; 2.5% ($20–60); 4% ($60–100); 8% ($100–150); 10% (>150)	0% < $50; 5% at $100; 10% > $150 (linear interpolation)
Tax regime	PPT at 50% on chargeable profits	Hydrocarbon Tax (HT) + CIT at 30%
Cost consolidation / Deductibility	PSC-specific cost recovery; ITC/ITA 50%	Allows cost consolidation across assets; explicit non-allowable deductions

3.2.4 Analysis of production profile

The production data is calculated below

Table 4: Production Data

Input variables			Calculated values		
Discovery potential	570	MMbbls	Build up rate	-1.466	Per year
Time to plateau	6	Years	Cum. Prod. for buildup phase	111.359	MMbbls
Initial prod. Rate	1000	Bpd	Cum. Prod. for plateau phase	160.752	MMbbls
Max. prod. Rate	150,000	Bpd	Cum. Prod. for decline phase	295.535	MMbbls
Plateau period	3	Years	Overall production	567.646	MMbbls
Effective decline rate	12.5	% per year			

As proposed by Main (2002) a fixed value of 5% of CAPEX and a value of 1% variable was adopted as operating expenditure as a rule of thumb. The capital allowance used for tax purpose calculation apply a five year straigthline depreciation method. A price escalation rate of 2% per annum was used expressed in nominal rate. The rate use for depreciation is 20% for the first four years and 19% was allotted to the fifth year and 1% was used as abandonment reserve value for the last year of the asset life.

3.2 5 Computation of profitability indicators

Net Present Value (NPV): The criteria for accepting NPV values positive value meaning value is being added so accept project but is NPV is negative it means value is being destroyed and the projected should be rejected. The equation below is used as presented by (Mian, 2011).

$$NPV = \sum_{t=1}^{k} \frac{NCF_t}{(1+r)^t} \qquad (3.25)$$

NCF_t is the end of year cash receipts annually
r represent the alternative use of available cash recognise as a rate
t is represented as the time in years

k represents the lifetime (in years) of the venture.

Internal Rate of Return (IRR): When funds are borrowed the IRR should always be of a higher value than the amount interest paid for loan acquisition. The equation below is used to compute IRR as presented by (Mian, 2011).

$$NPV = \sum_{t=1}^{k} \frac{NCF_t}{(1+IRR)^t} = 0$$

Payout period (PO): The time at which in years when all the initial investment have been totally recovered is referred to as the payout period.

Profitability Index (PI): This is the ratio of the present value of yet to be actualize future cash on the present worth of the investment it is a dimensionless value. A PI value greater than 1 is always considered in choosing an investment. The equation below is used to compute PI as presented by (Mian, 2011).

$$PI\,(f, F) = 1 + \frac{NPV\,(f, F)}{PV\ of\ CAPEX}$$

III. RESULTS AND DISCUSSION

The Production Sharing Contract Amendment Act 2019 and the 2021 Petroleum Industry Act (PIA, 2021) was modeled using the deterministic analysis in the current chapter as all the models highlighted in chapter three were used to carry out the analysis. The input variable and other variable were used to analyzing the models.

4.1 Deterministic Results

A proper results comparison of profitability indicators of PIA 2021 and PSC 2019 is shown in table 5.

Table 5: AIT Deterministic Discounted results for PIA 2021 and PSC 2019

Profitability Measures	PIA 2021	PSC 2019
Net Present Value @15% (MM$)	595.18	645.82
Internal Rate of Return	23.7%	22.0%
Present Value Ratio	0.34	0.23
Profitability Index	1.34	1.23
Growth Rate of Return	16.3%	15.9%
Contractor Take	11.9%	17.8%
Government Take	88.1%	82.2%

The results shown in table 4.2, clearly shows that the PIA (2021) fiscal policy yields higher government take of 88.1% higher than 82.2% computed from the fiscal policy of PSC Amendment Act (2019). All other profitability factor were also positive gain to the federal government.

4.2 **Profitability Indicators for Deterministic Analysis**

Common economic instruments and their decision criteria for projects economic viability in the oil and gas industry are shown in table 6.

Table 6: Capital Decision Rules Budgeting (Iledare O. 2019)

Profitability Measure	Accept If @ r*	Reject If @ r*
NPV	>0	< 0
IRR	> r*	< r*
PI	>1	<1
PVR	>0	<0

The PIA 2021 fiscal framework used in this research gave an NPV of 595.18MM$ and the PSC fiscal framework gave 645.82 MM$ which is indicative of value being created additionally. The NPV value is at 15% discount rate is a positive value. The interpretation of the positive NPV is that the cost of financing the project was paid off and also the cost of alternative use. The PIA (2021) fiscal regime model in this research gave an IRR of 23.7% which is above the opportunity cost of capital employed in the project, this deepwater investment under tis PIA (2021) is profitable as such it should be embark upon. Same is the PSC 2019 as it gave 22.0%. Also, for this particular venture the profitability index generated is 1.34 **PI > 1).** For an upstream investment this is good as the investment recover the money invested in it and a gain of 0.3 was made from it. The PSC 2019 gave a profitability index of 1.23. The PVR is a deterministic indicator and under this investment it yielded a value of 0.34, and that of PSC 2019 is 0.23 which is greater than 0 which clearly states that both ventures are profitable and is worth investing in.

4.3 Monte Carlo Simulation Results for some Selected Profitability Indicators.

From the results of the modeling there a base case of generating NPV of $595.18 million. from the investment it also shows a 50% certainty of raising $486.66 million worth from NPV there is 90% chance of generating NPV worth of $352.06. and $730.14 million NPV was generated within 10% likelihood as shown in Figure 1

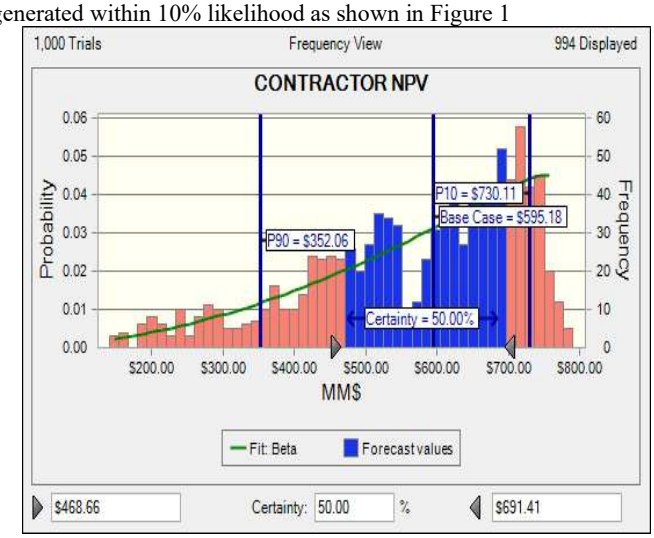

Figure 1: Stochastic Contractor NPV

From Figure 2, it was revealed that for every dollar invested there would be a dollar increase.

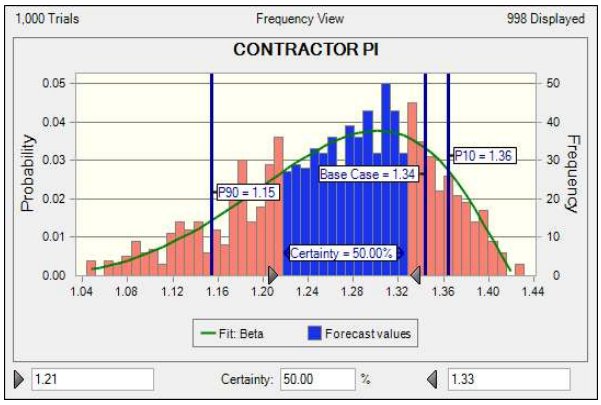

Figure 2: Stochastic Contractor PI

The PI value is between 1.21 and 1.33 at 50% certainty level. And the investment have an average value of 1.34. A profitability value of less than or equal to 1.36 at 10% certainty level and also there is 90% probability of having $1.15. from the investment

The simulation carried out shows the IRR value is within the threshold as shown in Figure 3 under the PIA (2021).

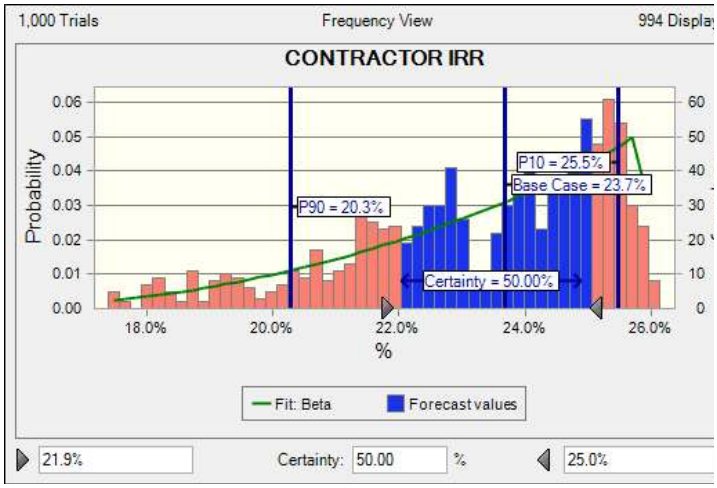

Figure 3: Stochastic Contractor IRR

An IRR value of between 21.9% and 25.0%. was obtained at 50% certainty level and 23.7% average value of IRR. IRR values of 20.3% and 25.5% were obtained at P90 and P10 respectively. The P90 value of 20.3% IRR is higher than the threshold of 15% rate of return so is appropriate to embark on the investment.

The PIA (2021) shows its profitable for the investor to invest in the venture as shown in Figure 4

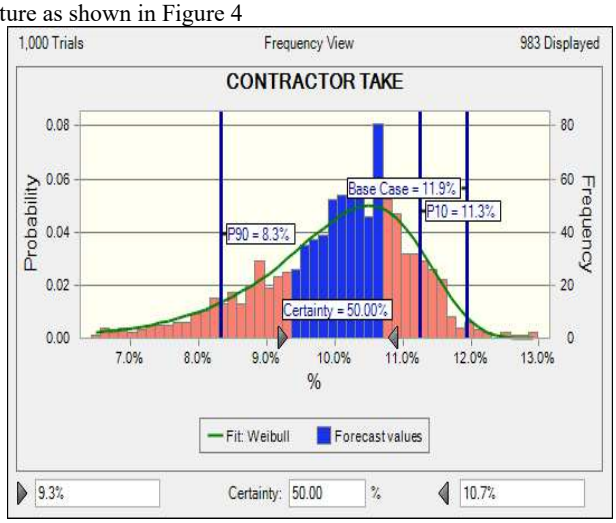

Figure 4: Stochastic Contractor Take

At 50% certainty the contractor a take that lies between 9.3% and 10.7% and also 8.3 percent take at certainty level of 90% and at 10% certainty level a take of 11.3%.

The host government take is shown in fig 5.

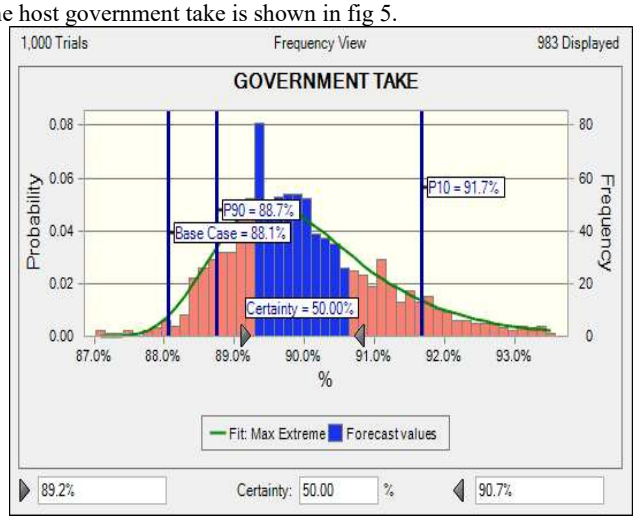

Figure 5: The Stochastic Government Take

From Figure 5, the government take is between 89.2% and 90.7% at 50% certainty which is a robust investment for the government. The government take is 88.7% at 90% certainty and a take of 91.7% at 10% certainty.

The variable considered of utmost import for both the Government and Contractor take that could have the highest impact are inflation rate, RRR, discount rate, oil price and PO split. Results of the Tornado charts for both the government take and contractor take, what favors the government more than the contractor is the rise in oil price. The additional petroleum income (APIT) that brings about recouping profit in case of windfall from oil price. The only scenario that can continuously increase the contractor take is embarking on reserve replacement exercise to increase the reserve replacement ratio (RRR). The summary of results for sensitivity analysis are presently in Table 7

Table 7: Result for the Sensitivity Analysis of the impact of input variable on profitability indicators.

Contractor NPV		Contractor IRR	
Input Variable	**Effect**	**Input Variable**	**Effect**
Discount rate	-	Oil price	+
Oil price	+	PO/Cont	+
PO/Cont	+	RRR	+
RRR	+	CRL	+
Inflation rate	+	Inflation rate	+

Contractor Take		Government Take	
Input Variable	**Effect**	**Input Variable**	**Effect**
PO/Cont	+	PO/Cont	-
Oil price	-	Oil price	+
Discount rate	-	Discount rate	+
RRR	+	RRR	-
Inflation rate	-	Inflation rate	+

5 CONCLUSION

In this study, an overview of Production Sharing Contract (amendment) Act 2019 and PIA 2021 Act was analysed. The following conclusions could be made;

i. Cash flow models were developed for both regimes and used for the project economic evaluation.
ii. Project economics under both regimes were analyzed.
iii. Profitability indicators were favorable under both regimes as Petroleum Industry Act 2021 increased Government take from 82.2% to 88.1%.
iv. Determination of uncertainties and risks using Stochastic simulation was incorporated successfully in the economic model which made it unique, and shows clearly the input variables which affect the various profitability instruments.

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