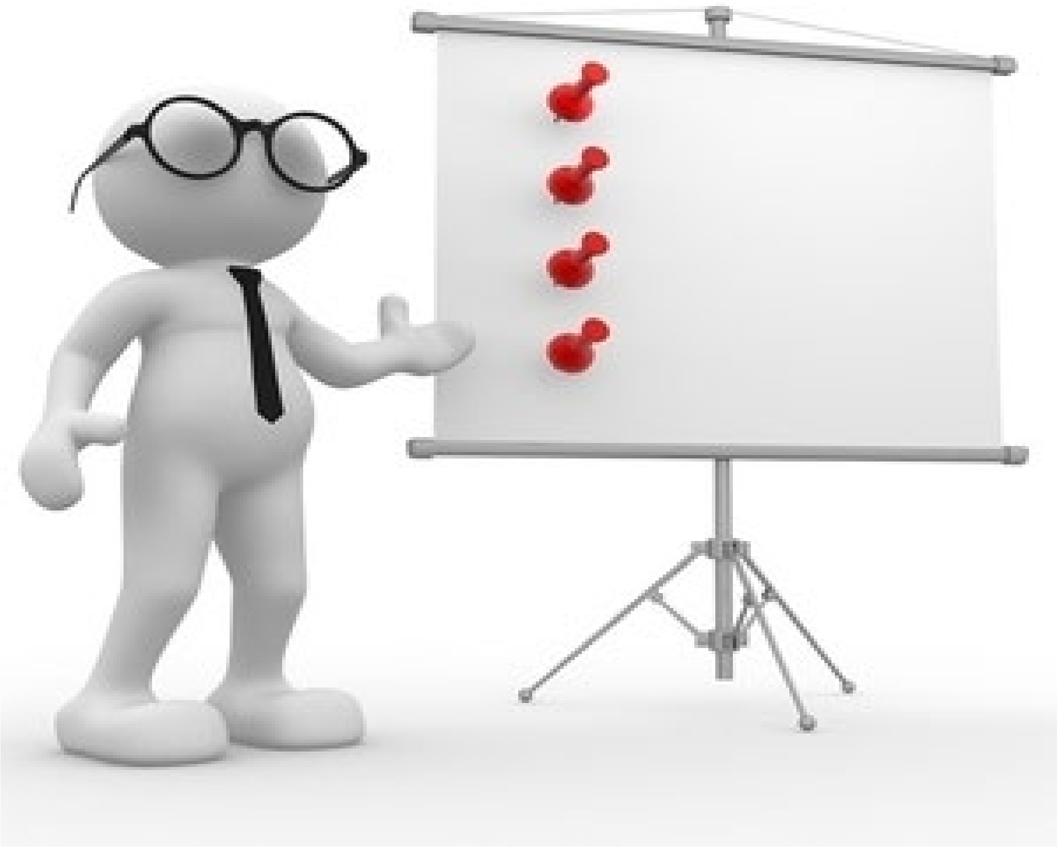
ESTIMATING UPSTREAM UNIT PRODUCTION COST FOR OPTIMAL ALLOCATION OF CRUDE OIL: A CASE STUDY OF NIGERIA

By
Kaase Gbakon
Joseph Ajienka
Joshua Gogo
Omowumi Iledare

Presented at the
6th AIEE Energy Symposium on Energy Security 2021
December 14^{th} – 16^{th} 2021

Theme: The energy transition, a pathway from low carbon to decarbonization

TABLE OF CONTENTS

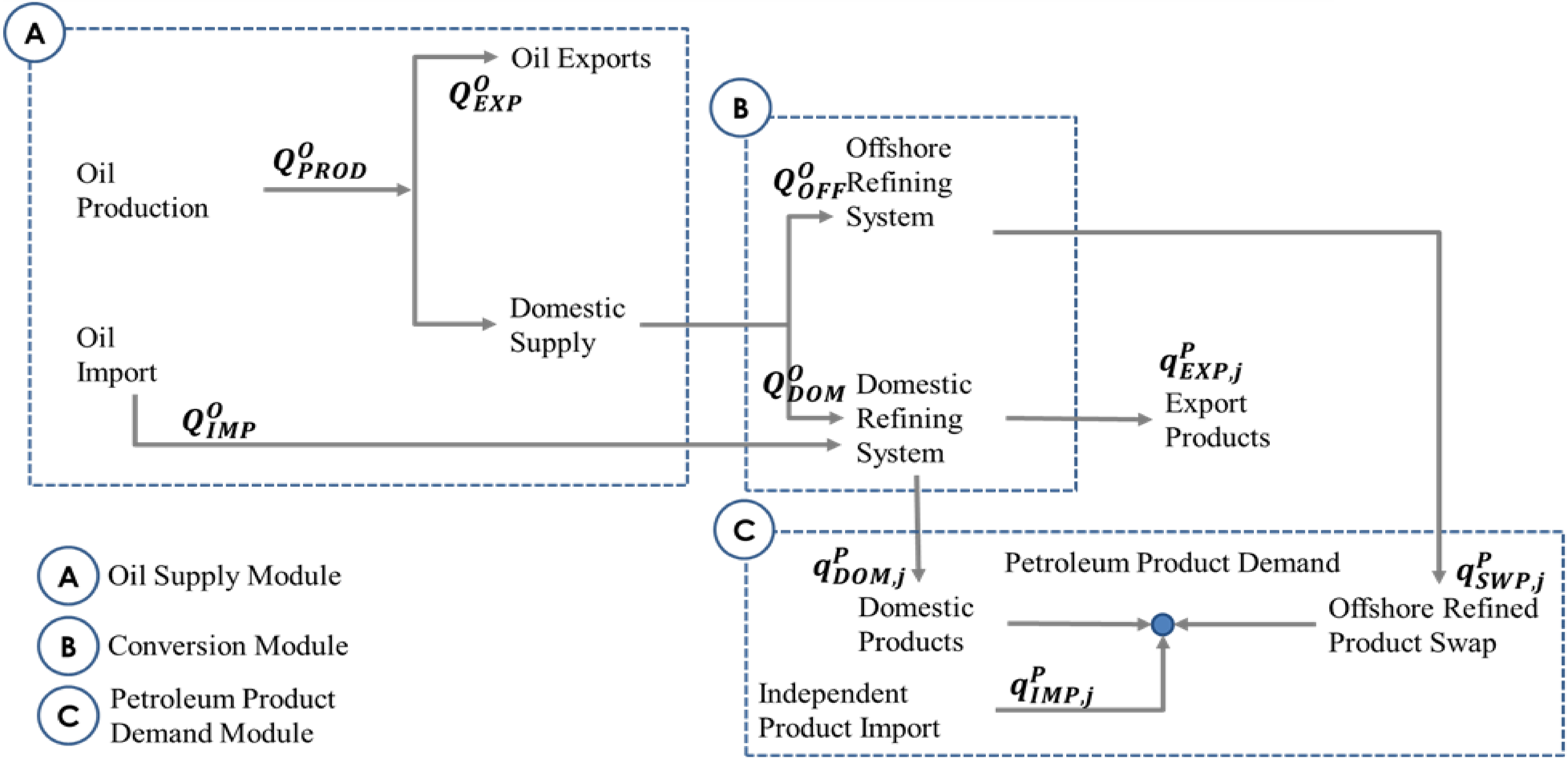


INTRODUCTION

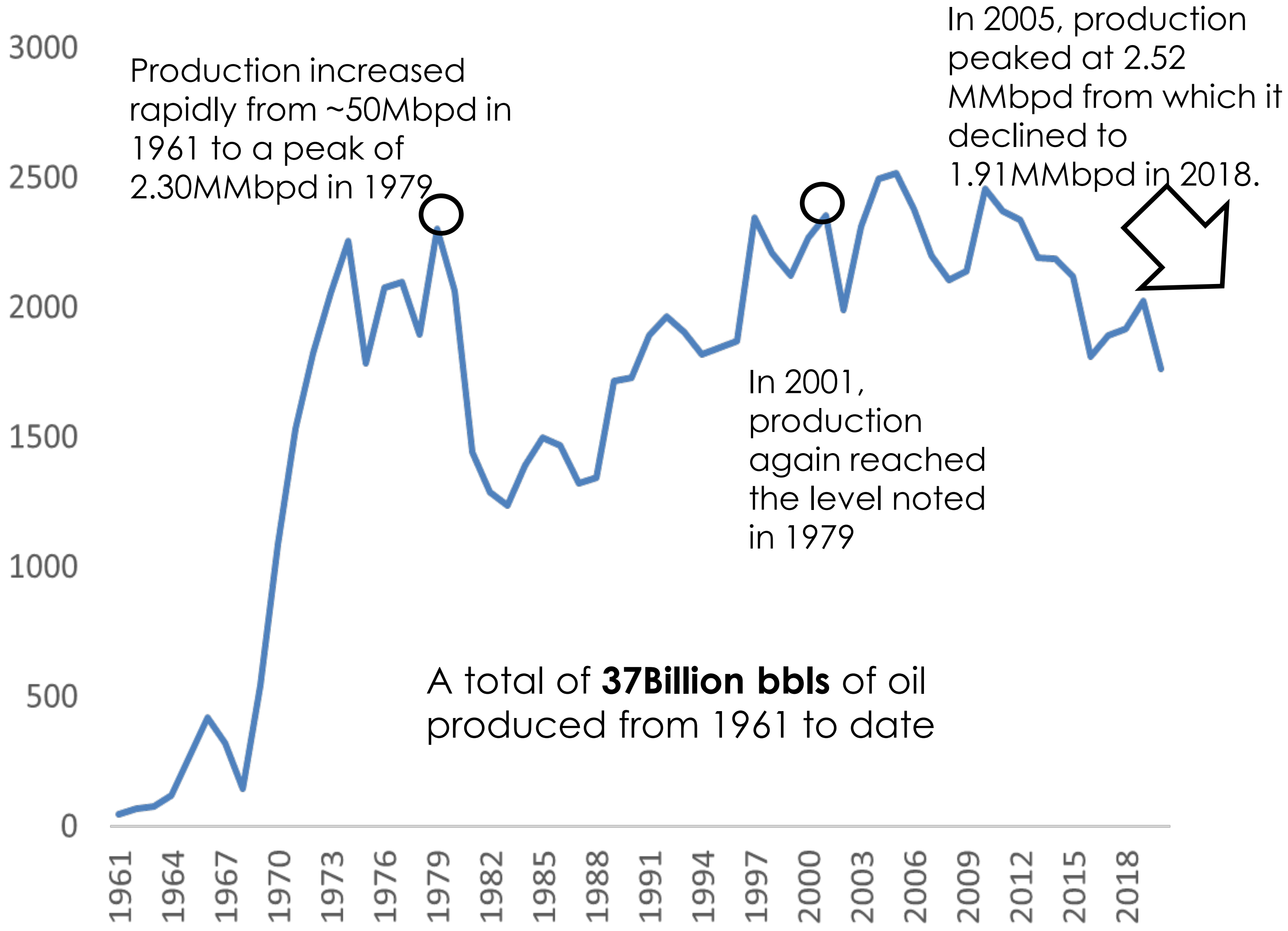
- Optimal allocation of crude oil to different end uses is an important consideration for Nigeria
- This is key for the conversation on energy transition for an oil dependent, developing country
- In our research we have developed mathematical programme for the optimal allocation of crude oil to different utilization options
- Upstream production cost is critical to the evaluation of the optimal resource distribution
- For energy systems modelling, inclusion of the cost of extracting or procuring the energy resource is a critical parameter for the optimization of the energy systems

The main aim of this paper is to estimate the upstream production cost which is a key parameter of the mathematical model

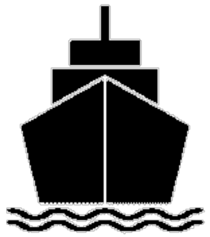
INTRODUCTION: Framework for Crude Oil Utilization



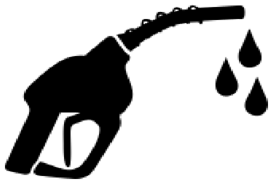
INTRODUCTION: Oil Production Profile



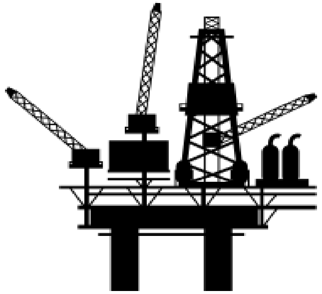
National Oil Production - Nigeria



Part Production goes to export. A high ratio

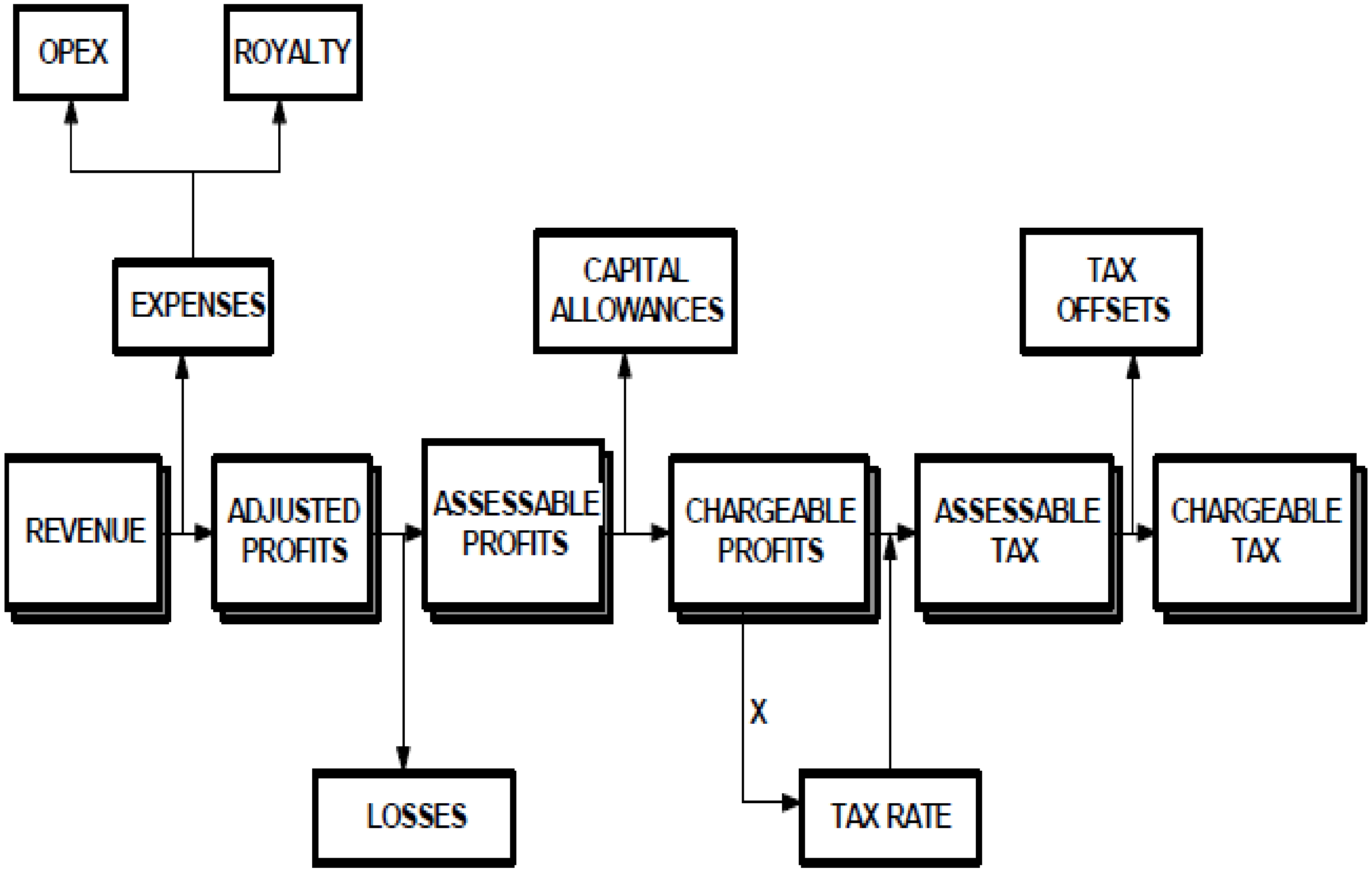


Part production also to domestic fuel supply



Cost of production is critical to the optimal allocation above

METHODOLOGY: Basis for Upstream Cost of Production



Schema for Tax Computation as per PPTA (Okon, T.E., 2006)

STEPS:

1. Translate the schema into mathematical formulation of the relationship between costs and tax payments
2. Relevant data (Oil Price, Oil Production, Royalty, Tax payment) is used within mathematical formulation to obtain unit cost
3. Develop a model of unit costs using oil price and oil production as explanatory variables to enable forecasts

Estimate Costs based on Petroleum Tax receipts as per schema

METHDOLOGY: The Cost Model

$$COST_t = P_t^O Q_t^O - ROY_t - \left[\frac{PPT_t}{R_{PPT}}\right]$$

Where:
- $\boldsymbol{P_t^O}$ is the Oil Price
- $\boldsymbol{Q_t^O}$ is the Oil Production
- $\boldsymbol{ROY_t}$ is the Oil Royalty
- $\boldsymbol{COST_t}$ is the Production Cost
- $\boldsymbol{PPT_t}$ is the Petroleum Profit Tax receipts
- $\boldsymbol{R_{PPT}}$ is the Petroleum Profit Tax rate

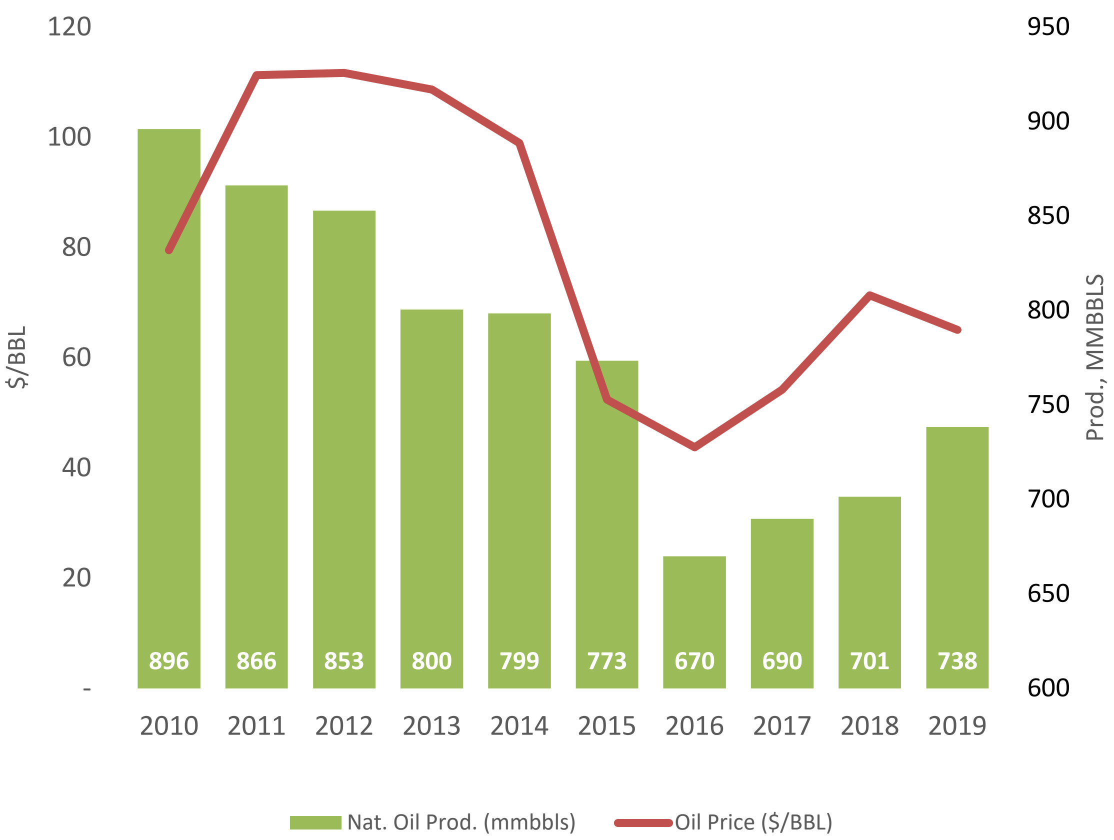
S/N	Variable	Data Source
1	Oil Price	NNPC ASB, F&O Reports
2	Oil Production (Nigeria)	NNPC ASB, F&O Reports
3	Oil Royalty Payments	Department of Petroleum Resources (DPR), CBN
4	Petroleum Profit Tax (PPT)	FIRS, CBN
5	Tax Rates	Petroleum Profit Tax Act

Data and Corresponding Sources

ASB: Annual Statistical Bulletin
CBN: Central Bank of Nigeria
DPR: Department of Petroleum Resources
F&O: Finance and Operations
FIRS: Federal Inland Revenue Service
NNPC: Nigerian National Petroleum Corporation

The data sourced above is input into the relationship to estimate Costs.
Unit Costs is then regressed against Oil Price and Production to enable forecasts.

RESULTS: Profile of Production, Price, Royalty and Tax Receipts



- Production has been on a downward trend from 2010
- Royalty and Tax receipts have also declined in that same period
- Royalty fell from $4.6B in 2010 to $3.34B in 2020
- Petroleum Tax fell from a high of $20.6B in 2012 to ~$4B in 2020

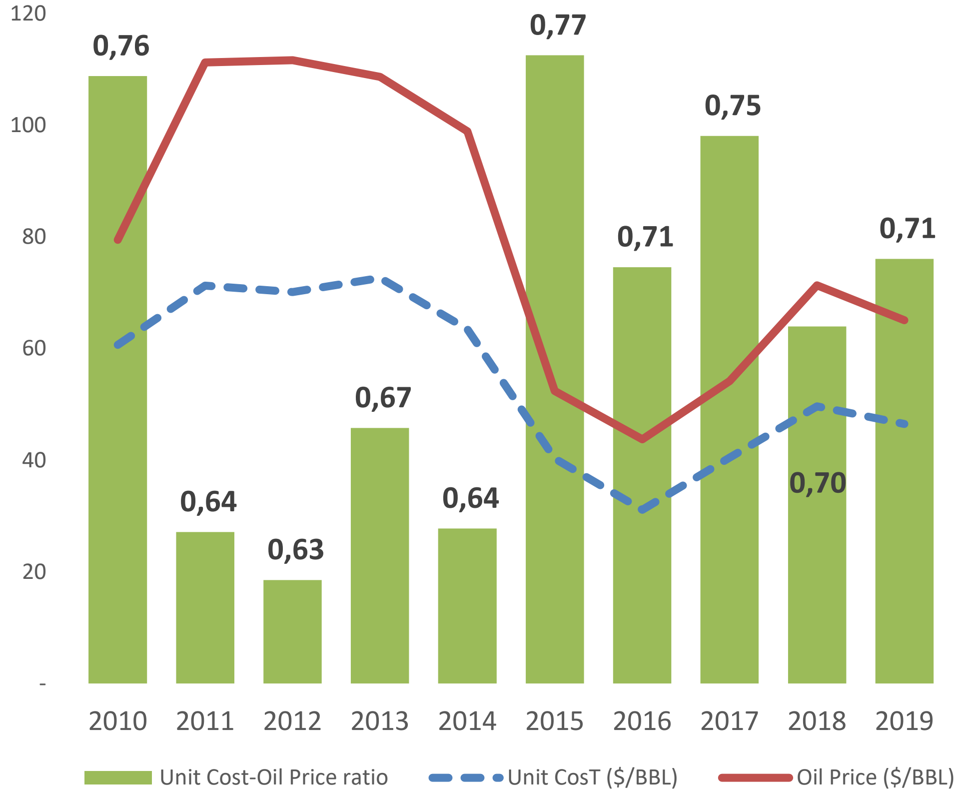
RESULTS: Descriptive Statistics of Key Variables

	Oil Price ($/BBL)	Nat. Oil Prod. (MMBBLS)	Royalty ($MM)	PPTax ($MM)	Wgtd PPTax Rate
Mean	76.25	766.46	4,449.00	10,418.00	0.71
Median	71.31	773.46	3,934.20	8,061.30	0.71
Minimum	41.96	643.94	1,732.50	3,994.70	0.68
Maximum	111.67	896.04	7,004.10	20,617.00	0.73
Std. Dev.	27.38	84.65	1,857.10	6,480.60	0.01
C.V.	0.3591	0.1104	0.4174	0.6221	0.0204
Skewness	0.1671	0.0693	0.0702	0.5614	-0.2529
Ex. kurtosis	-1.5267	-1.2773	-1.3856	-1.3127	-0.1490
IQ range	56.27	163.03	3,457.70	11,531.00	0.02

- Monte-Carlo simulation employed to estimate regression coefficients for the model of unit cost (UC)
- Functional form of UC as a function of oil price and oil production

$$UC = K + A_1 P^O + A_2 Q^O$$

RESULTS: Derived Unit Cost



	Oil Price ($/BBL)	Oil Prod (MMBBLS)	Unit Cost ($/BBL)
Oil Price ($/BBL)	1.0000	0.7397	0.9915
Oil Prod. (MMBBLS)		1.0000	0.7760
Unit Cost ($/BBL)			1.0000

Correlation Coefficients, Using the Observations 2010 - 2019

- The UC exhibits the stronger correlation with oil price (at 0.99) compared to oil production (correlation of 0.78).
- There is also a strong positive correlation of 0.74 between oil production and oil price.
- We estimate that Unit cost is ~70% oil price (average over the period)

RESULTS: OLS, using 1,000 simulation trials / observations

Dependent variable: UC

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
K	−57.3676	3.31980	−17.28	<0.0001	***
P^O	0.995976	0.0144202	69.07	<0.0001	***
Q^O	0.0381809	0.00399160	9.565	<0.0001	***

Mean dependent var	49.05964	S.D. dependent var	21.69652
Sum squared resid	81120.40	S.E. of regression	9.029288
R-squared	0.827156	Adjusted R-squared	0.826808
F(2, 995)	2444.228	P-value(F)	0.000000
Log-likelihood	−3610.671	Akaike criterion	7227.342
Schwarz criterion	7242.059	Hannan-Quinn	7232.936

- To forecast costs for the optimization model, we estimate a cost model based on meta-analysis.

KEY CONCLUSIONS…

- The cost estimation approach used utilizes tax receipts to infer industry costs.
- Historically we find that unit costs range 63% - 77% of oil prices
- Estimated model of unit cost as a function of oil price and oil production, to forecast of upstream oil production costs
- Model is useful for performance reporting, budgeting, tax forecasting and energy system modelling.

END