Probabilistic Estimation of Underground Reserve and Economic Output

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Objective

- To develop a probabilistic estimation and economic analysis of a given reservoir.

Input Parameters

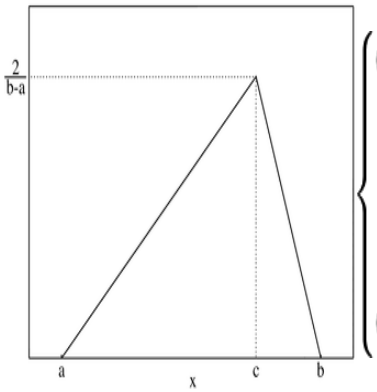
Parameters	Min	Mode	Group 06 Mode	Max
Area, A (acre)	10000	10500	10968	12000
Thickness, h (ft.)	30	80	83	100
Porosity,	0.1	0.22	0.222	0.3
S_o	0.4	0.6	0.591	0.7
B_o (RB/STB)	1.15	1.2	1.25	1.3
Recovery Factor	0.1	0.15	0.16	0.3
Price ($/B)	30	80	84	120
Years	20	25	27	30
Cost ($/B)	10	20	20	40
Discount Rate (r_d)	0.1			

$$OIIP = \frac{43560 A h \phi S_o}{5.615 B_o}$$

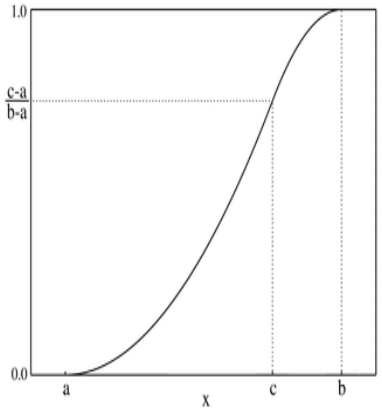
$$\text{Reserve} = OIIP \times RF$$

Calculating CDF & PDF

- The probability density function is used to determine the probability that the random variable falls in some range.
  - Calculate height by 2/b-a
  - Calculate slope before and after mode
  - Plot the graph f(x) vs x
  - Repeat for all parameters
- The cumulative distribution function is the probability that the variable takes a value less than or equal to x.
  - Get the equation for F(x) before and after mode.
  - Generate random number to get the value of x using F(x) equation.



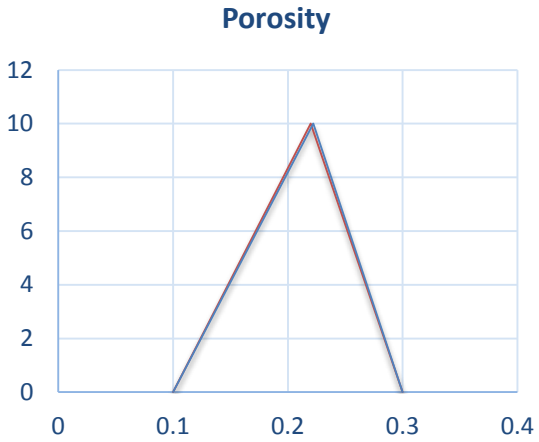
$$\begin{cases} 0 & \text{for } x < a, \\ \frac{2(x-a)}{(b-a)(c-a)} & \text{for } a \le x < c, \\ \frac{2}{b-a} & \text{for } x = c, \\ \frac{2(b-x)}{(b-a)(b-c)} & \text{for } c < x \le b, \\ 0 & \text{for } b < x. \end{cases}$$

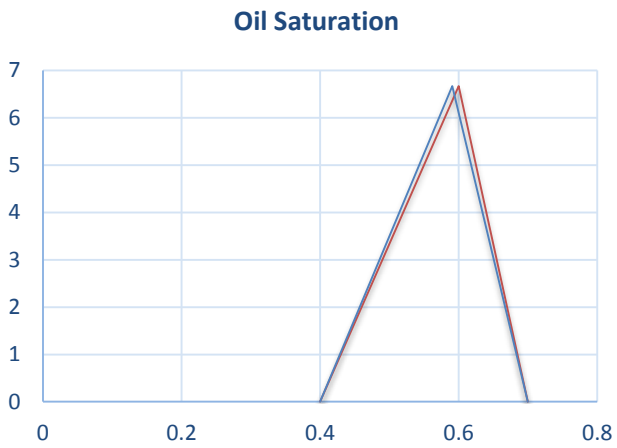


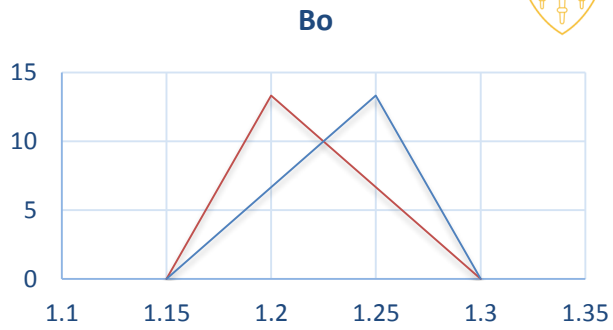
$$\begin{cases} 0 & \text{for } x \le a, \\ \frac{(x-a)^2}{(b-a)(c-a)} & \text{for } a < x \le c, \\ 1 - \frac{(b-x)^2}{(b-a)(b-c)} & \text{for } c < x < b, \\ 1 & \text{for } b \le x. \end{cases}$$

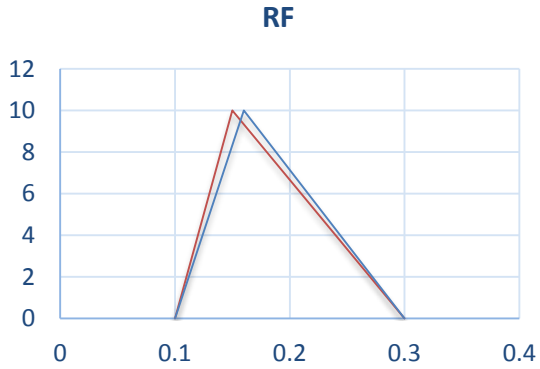
Parameters	Max (Base Mode)	Min (Base Mode)	Max (Group Mode)	Min Case (Group Mode)
OOIP	1493608695	85498908.5	1494021334	85550717.3
Reserves	445407934.8	8598188.77	445621706.1	8608011.51
NPV	11213425592	76156938.4	11217072530	76321677.3

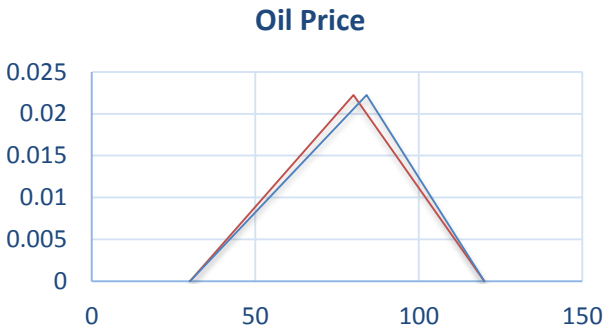
PDF Plots Comparison

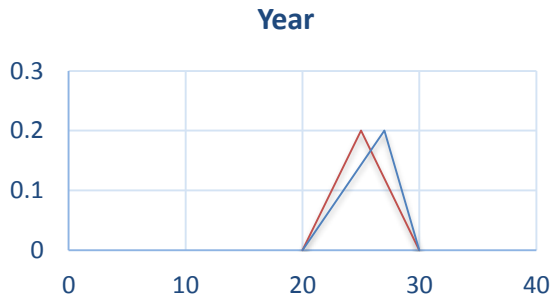


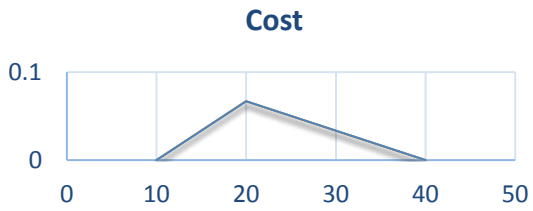


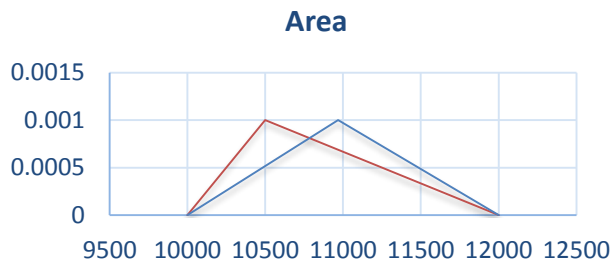


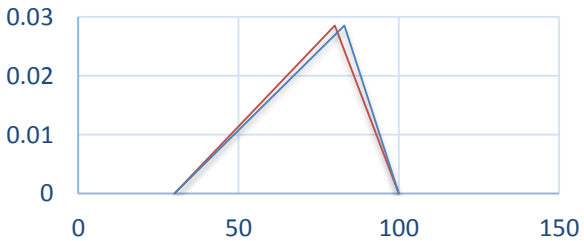




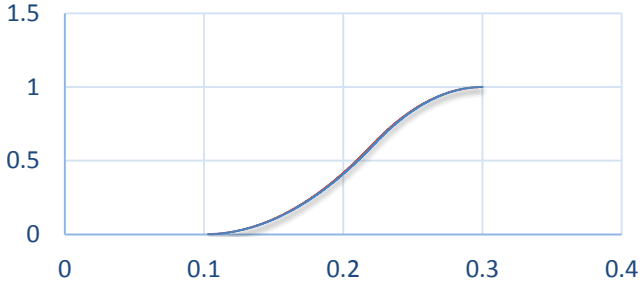


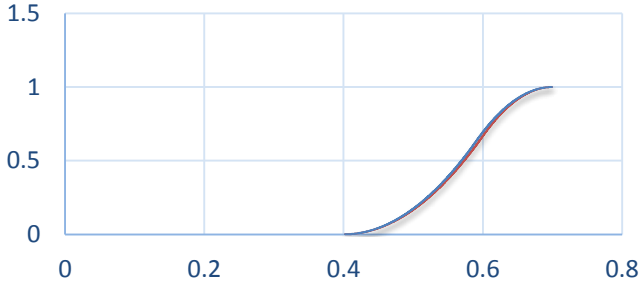


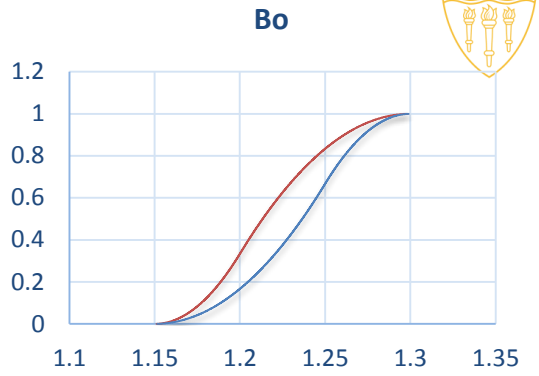


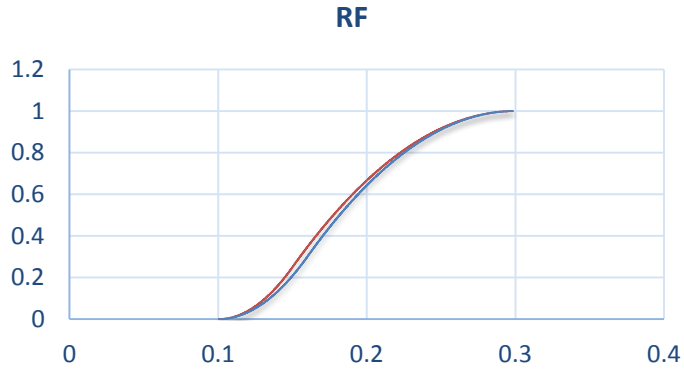


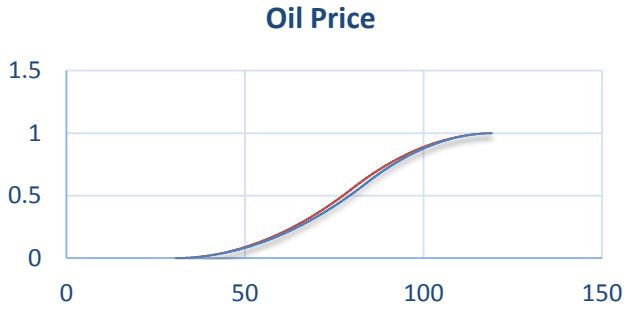
CDF Plots Comparison

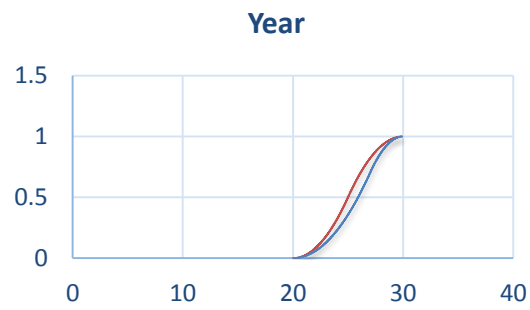


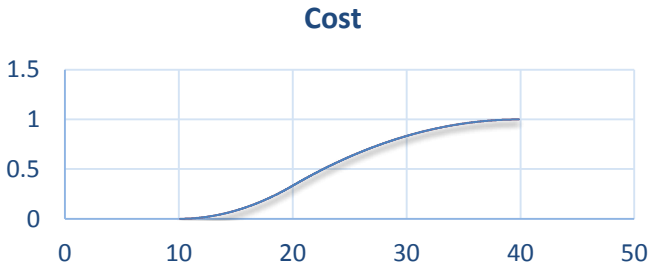


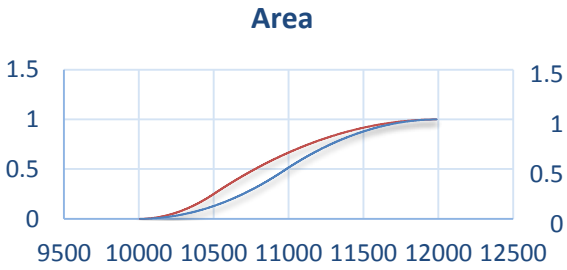


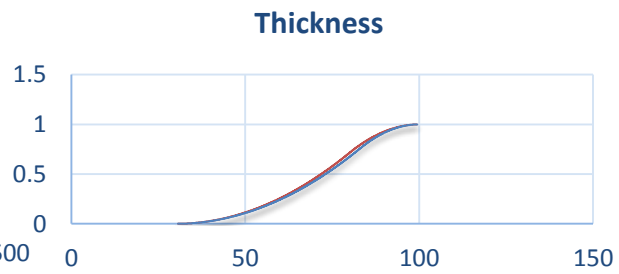




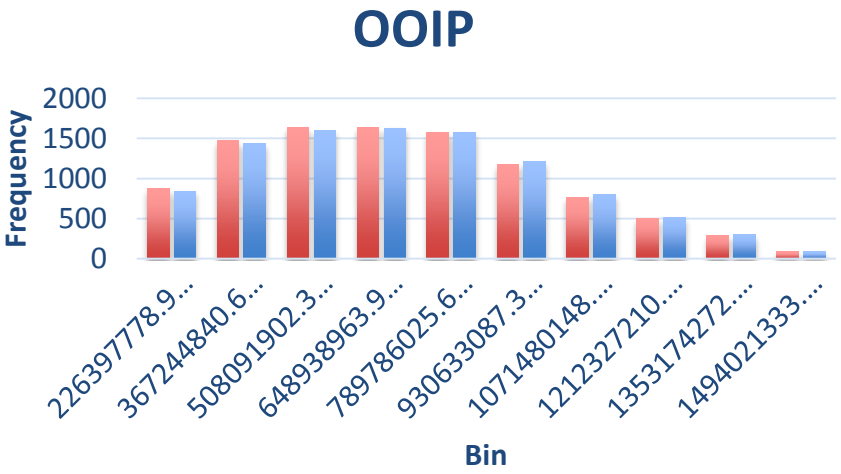


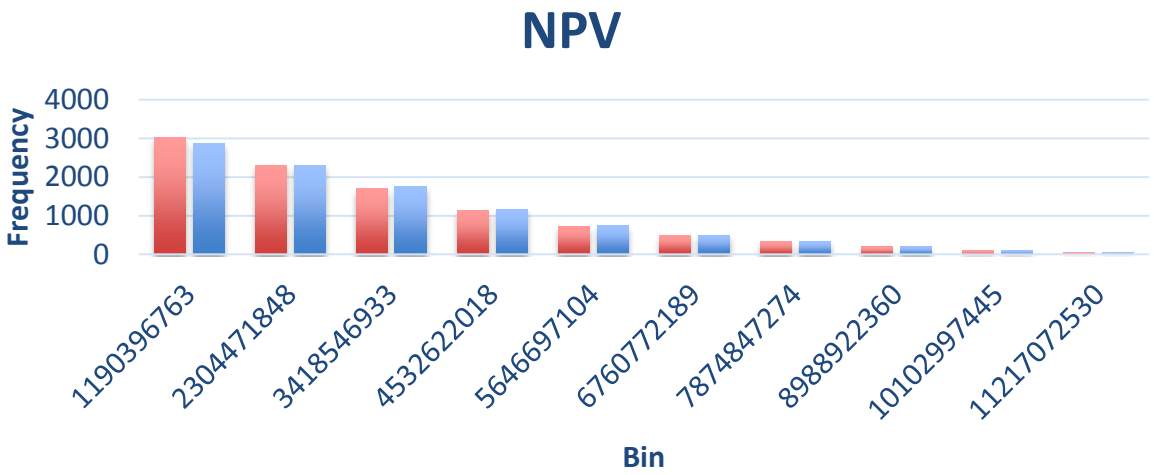






Histogram Comparative Plots





Results, Thoughts and Suggestions

- CDF comparison curves plots for all the parameters doesn't deviate much with each other.
- According to me, 50% risk case works better which gives better value of NPV.

Result						
P(X<x*)	OOIP (Base)	Reserves (Base)	NPV (Base)	OOIP (Group)	Reserves (Group)	NPV (Group)
0.010	34000000	2600000	65660000	20000000	4000000	80000000
0.050	130000000	15000000	220000000	180000000	20000000	320000000
0.100	220000000	22000000	400000000	230000000	30000000	400000000
0.500	600000000	104000000	2040000000	600000000	110000000	2200000000

Parameters	Max (Base Mode)	Min (Base Mode)	Max Case (Group Mode)	Min Case (Group Mode)	Standard Deviation (Base)	Standard Deviation (Group)	Median (Base)	Median (Group)
OOIP (STB)	1493608695	85498908.5	1494021334	85550717.3	29863587 4.2	3000236 17.5	595087 391.3	603924 100.6
Reserves	445407934.8	85981 8.77	445621 706.1	86080 1.51	87461524 .05	8803411 2.53	105733 133.5	109808 146.7
NPV	11213425 592	76156938.4	11217072530	76321677.3	21706246 46	2184135 136	211615 1369	437013 69.46

Thank you!