Notes to Youtube video 12

How to deal and quantify uncertainty in field development

for example in our Snøhvit case

↳ G, N , $q_g = C_R (P_R^2 - P_{wf}^2)^n$

$

uptime 90 – 100%

$\left(\frac{\text{nr days producing in year}}{365} \right)$

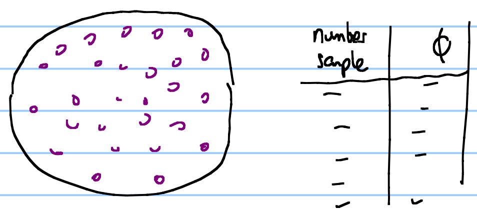
↳ cause additional OPEX

↳ cut in production → cut in Revenue

Input variables used in engineering studies in FD are highly uncertain

$\Phi_{min} \leq \Phi \leq \Phi_{max}$ and affect the value of KPIs that are used to discriminate and select development alternatives.

Φ



→ discrete frequency analysis

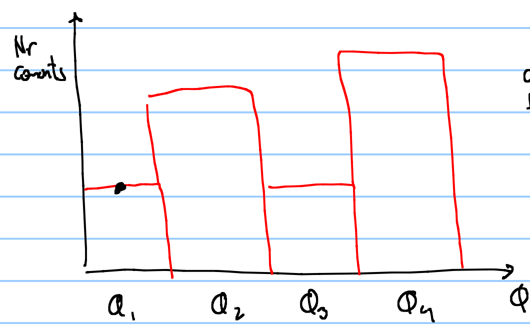
create bins

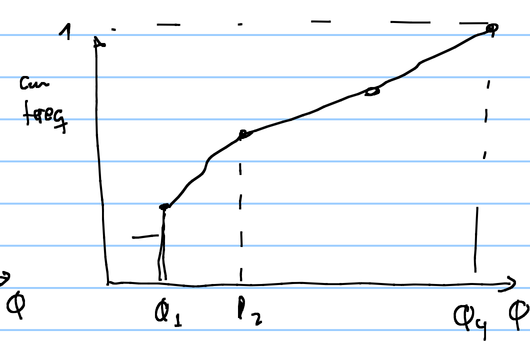
min Φ_1 (0.15) — 0.175 — if $\Phi_i = 0.18$

Φ_2 (0.20) — $\Phi_1 \leq \Phi_i \leq \Phi_2$

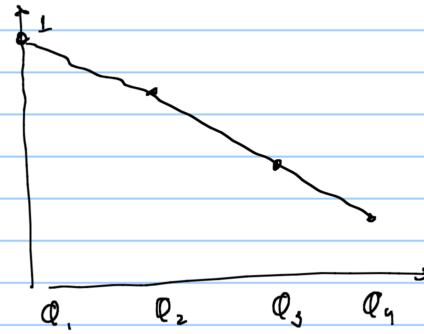
Φ_3 (0.25) — if $\Phi_i < \frac{(\Phi_2 - \Phi_1)}{2} + \Phi_1$ → counted as part of Φ_1

max Φ_4 (0.30)

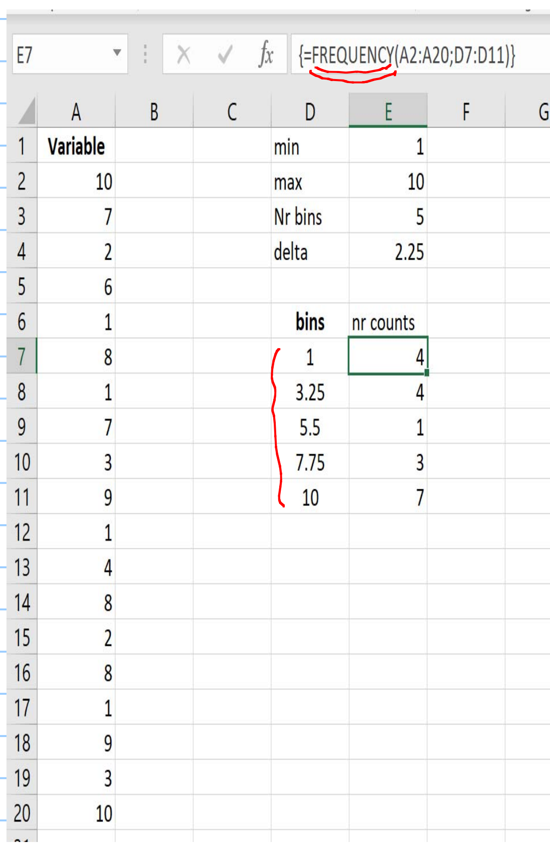




bin	Nr counts	rel. frequency	cum frequency	inv. cum frequency
Q_1	x	x/N	x/N	$(x+w+z+y)/N \rightarrow 1$
Q_2	y	y/N	$y/N + x/N$	$(w+z+y)/N$
Q_3	z	z/N	$y/N + x/N + z/N$	$(w+z)/N$
Q_4	w	w/N	$\frac{x+y+z+w}{N}$	w/N
	N			



how to do frequency analysis in excel:



E7 {=FREQUENCY(A2:A20;D7:D11)}

	A	B	C	D	E
1	Variable			min	1
2	10			max	10
3	7			Nr bins	5
4	2			delta	2.25
5	6				
6	1			bins	nr counts
7	8			1	4
8	1			3.25	4
9	7			5.5	1
10	3			7.75	3
11	9			10	7
12	1				
13	4				
14	8				
15	2				
16	8				
17	1				
18	9				
19	3				
20	10				

to create bins:

find max
find min
define Nr bins
calculate $\text{delta} = \frac{(\max - \min)}{(\text{Nr bins} - 1)}$

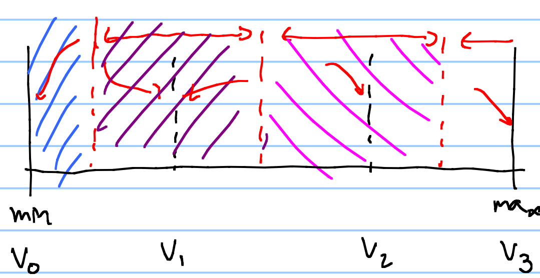
compute each bin
$\text{bin}^{i} = \text{bin}^{i-1} + \text{delta}$

starting from $\text{bin}^{0} = \min$

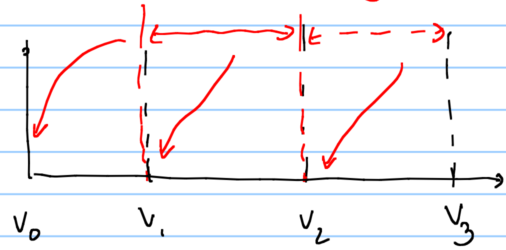
to apply frequency function:

ctrl + shift + enter (in sequence and leave it pressed)

selecting bins must take into account
- nr data points



be careful how the frequency is accounted for



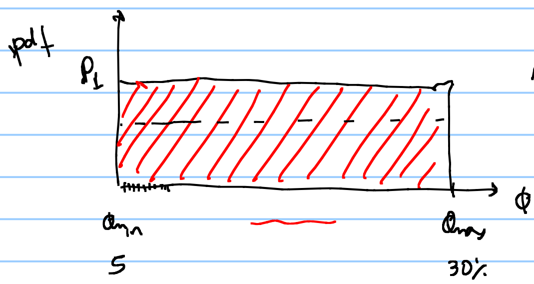
what happens if there are no measurements?

frequency ⇝ probability

rel frequency ⇝ pdf probability density function

cum frequency plot ⇝ cdf cumulative distribution function

poor boy, no data pdf ϕ continuous probability



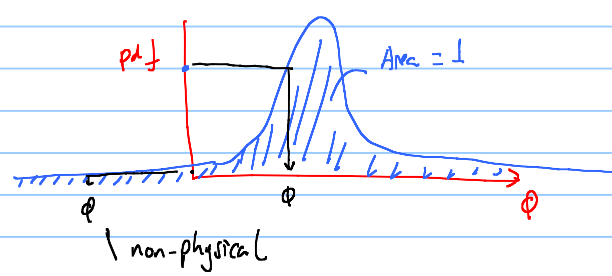
$$Area = (\phi_{max} - \phi_{min}) \cdot P_1 = 1$$

$$P_1 = \frac{1}{(\phi_{max} - \phi_{min})}$$

Continuous distributions are advantageous because:
-There is an analytical expression
-I need only few values to define the distribution
-There is no data to determine a discrete distribution

Warning: many continuous distribution go from $-\infty \rightarrow +\infty$

There are many parameters in FD that exhibit typical distributions:
-cost ---Normal
-Porosity --- Normal
-Initial oil/gas in place --- Log Normal



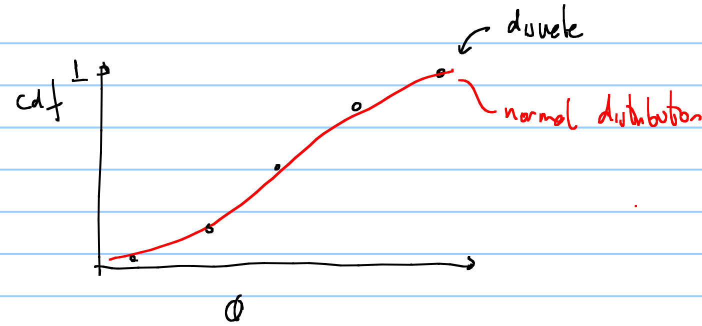
so bounding is necessary

discrete distribution ⟶ continuous distribution

- calculate directly using population data

$$\left.\begin{array}{c} \phi \\ \phi_1 \\ \phi_2 \\ \vdots \end{array}\right\} \begin{array}{l} \mu \\ \sigma \end{array} \rightarrow \text{parameters of a normal distribution}$$

- tune parameters in the continuous distribution to represent the discrete distribution

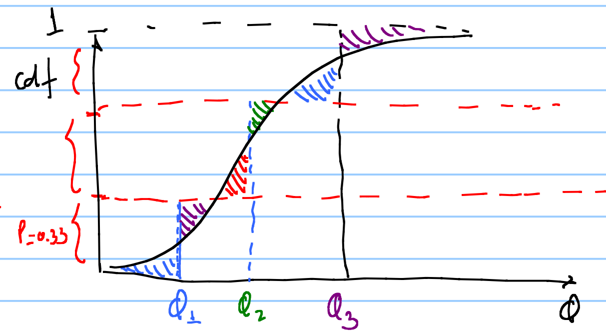


$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

change μ, σ until diff discrete and continuous is minimal

continuous distribution → discrete distribution

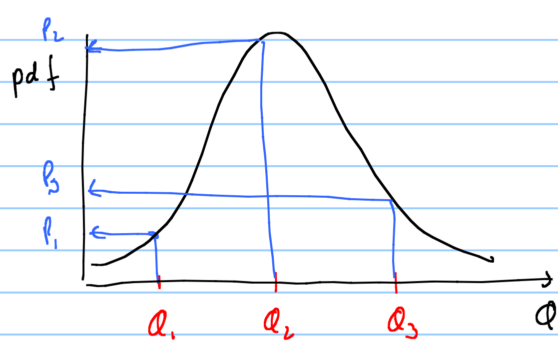
- Bracket mean
  - define nr. bins
  - define probability of bins



Φ	P
$Φ_1$	0.33
$Φ_2$	0.33
$Φ_3$	0.33

find $Φ_1$, such that [area] = [area]

- value discretization
- pick nr. bins in Φ
- read probabilities from pdf



Φ	P
$Φ_1$	P_1^*
$Φ_2$	P_2^*
$Φ_3$	P_3^*

- Normalize probabilities using the sum

$$P_1^* = \frac{P_1}{P_1 + P_2 + P_3}$$

$$P_2^* = \frac{P_2}{P_1 + P_2 + P_3}$$