Hydrocarbon volume prediction performance in the Dutch subsurface
&
the role of Survival Bias

Guido Hoetz

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- Synthetic Portfolio modelling
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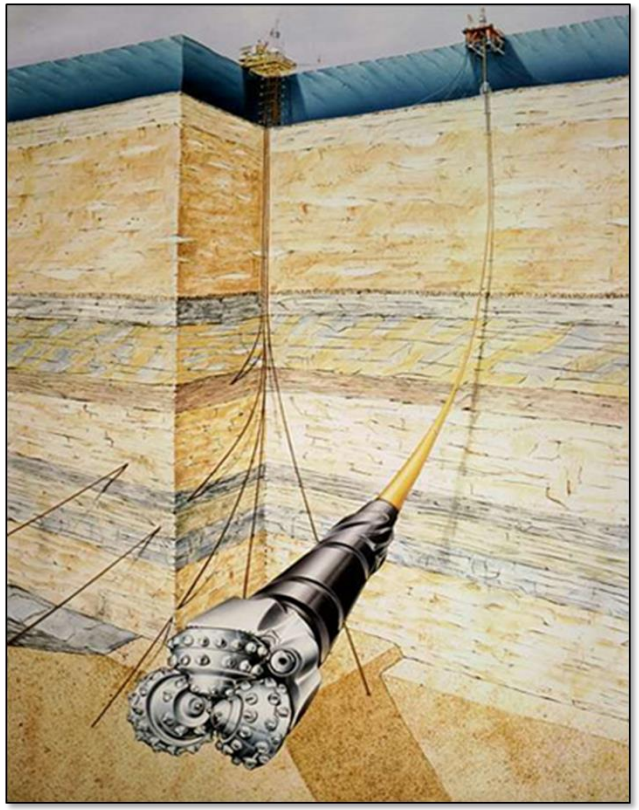


Introduction

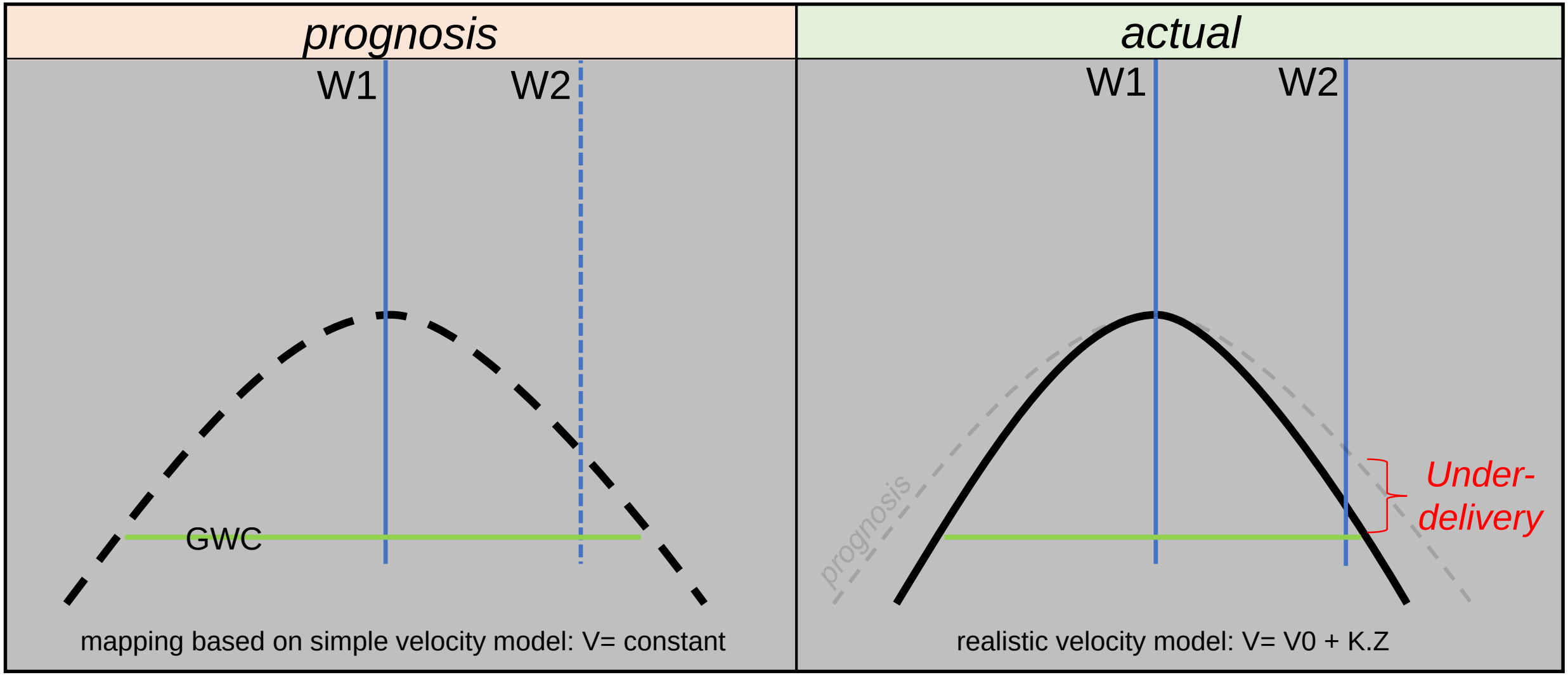
- Overpromise/underdelivery is a problem in the entire E&P industry. Especially in the area of hydrocarbon **volumetric predictions.**
- Well known amongst insiders. Yet literature is scarce.

Suggested causes are:

- *Evaluation Tool Bias* (e.g. inadequate seismic workflow)
- *Cognitive Bias* (e.g. individual motivational bias)
- *Survival (= Selection) Bias*

Evaluation Tool Induced Bias:

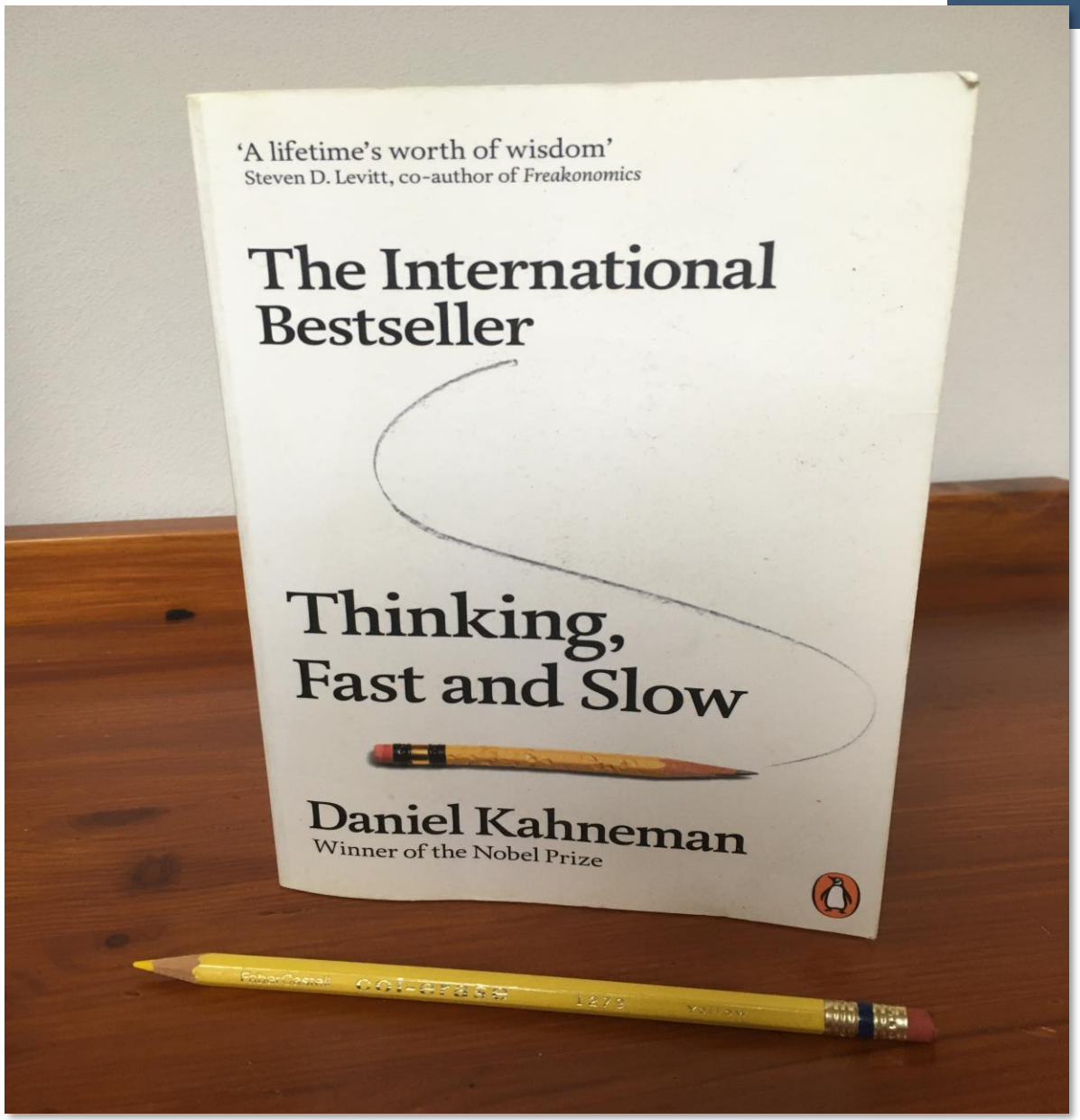
Example: *seismic mapping based on simplified velocity model*



Cognitive Bias

Extensively studied in behavioral science e.g:

- *Ancoring Bias*
- *Optimism Bias*



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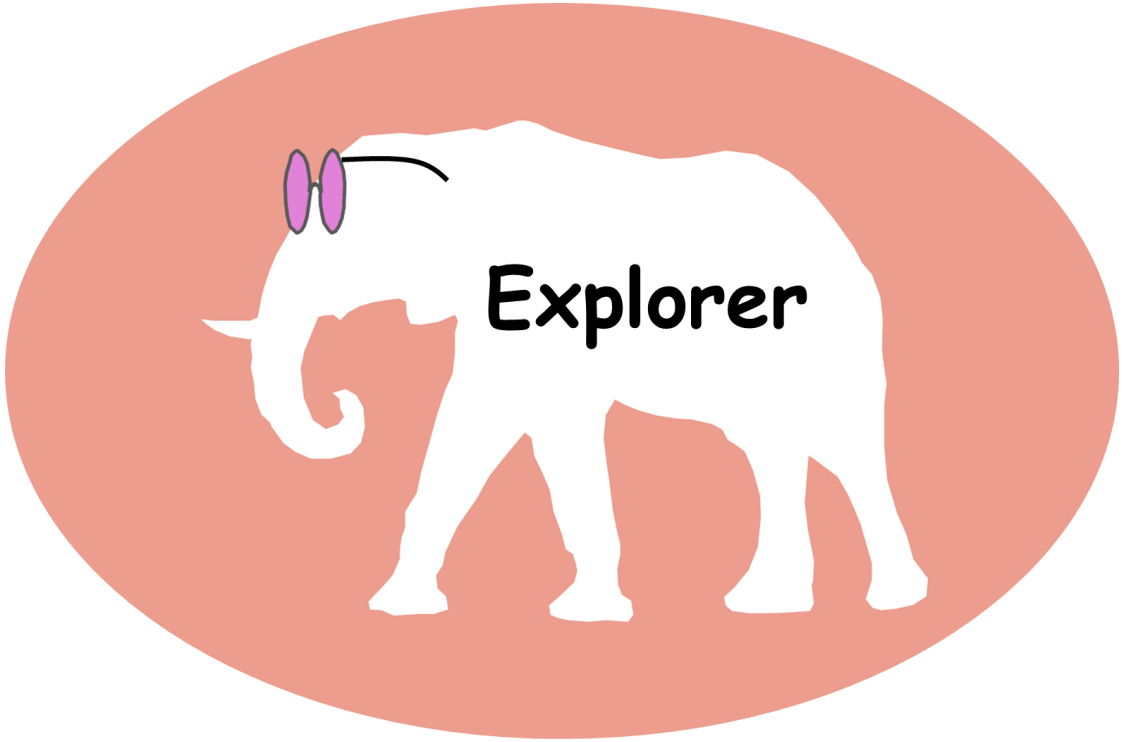
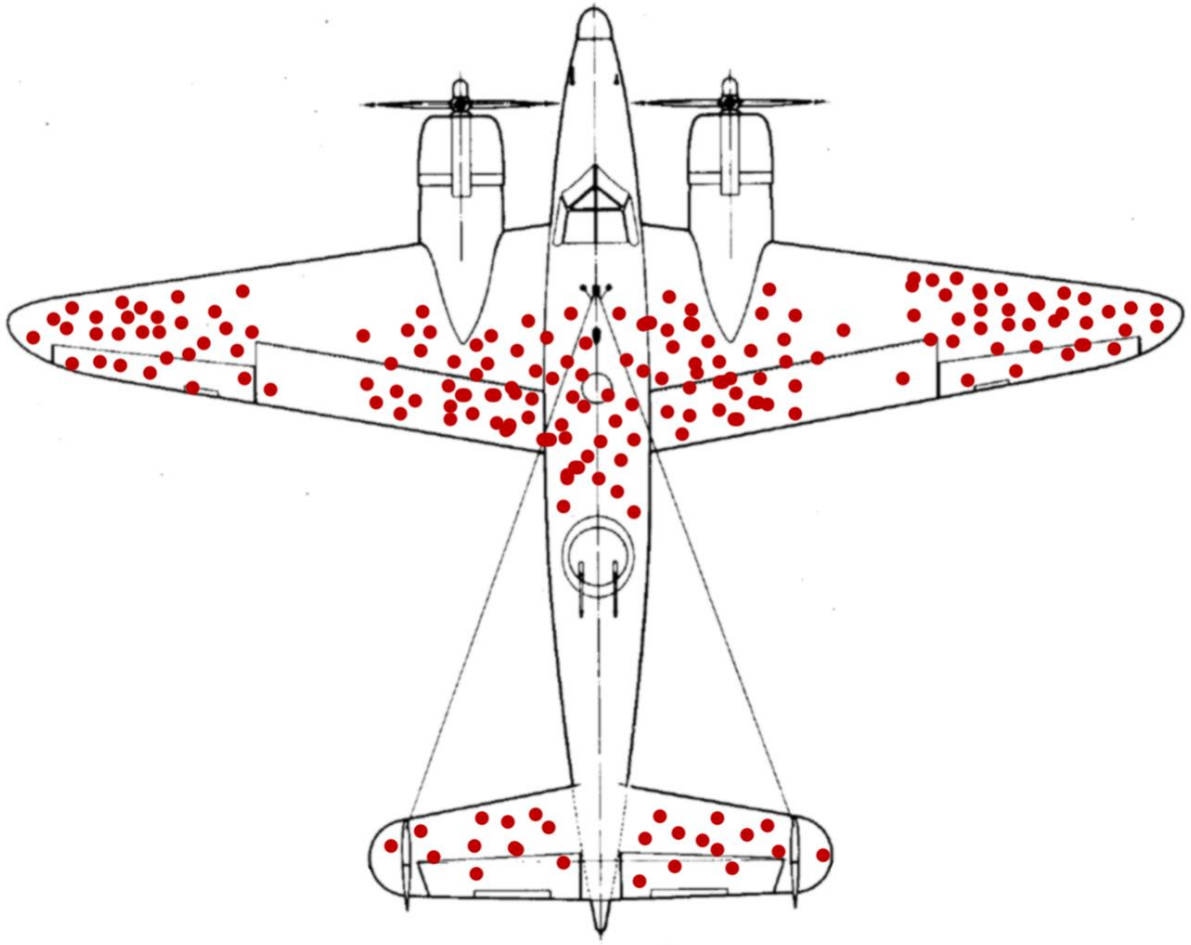


"White Elephants in a rosy picture wearing pink glasses"

classic *fallacy of* survival bias



So, where should you put the armour?

The commanders saw it clearly:
Put the armour where the most bullet holes are. That's where the planes are getting shot the most.

Shot impact damage as observed from many returning bombers

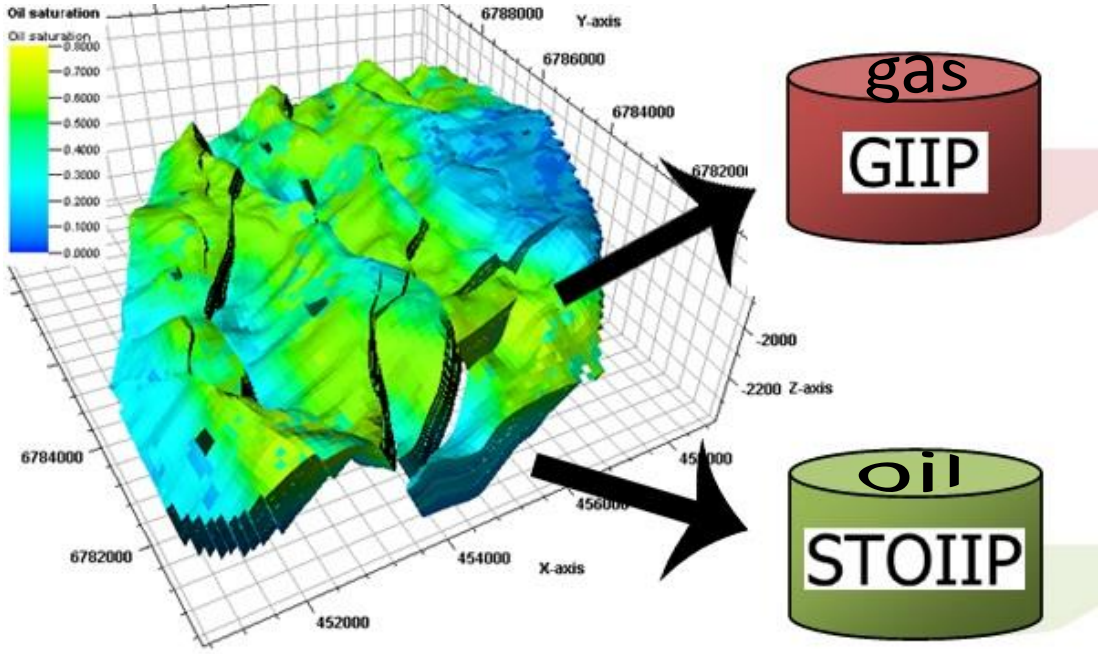
Volumes & risks

GIIP:	Gas Initially In Place
*	
RF:	Recovery Factor
=	
UR:	Ultimate Recovery
POS:	Probability of Success
*	
MSV:	Mean Success Volume
=	
EXP:	Expectation Volume

Statements

- Business cases for E&P drilling projects are based on *pre-drill estimates.*
- Companies that are more skilled in evaluation will prognose closer to *actuals.*
- Companies with better prognosis track-record will be more successful in the *long run.*

Volume predictions based on subsurface models



calculating gas volumes

Gas Initially In Place

Gross Rock Volume

Net to gross

Porosity

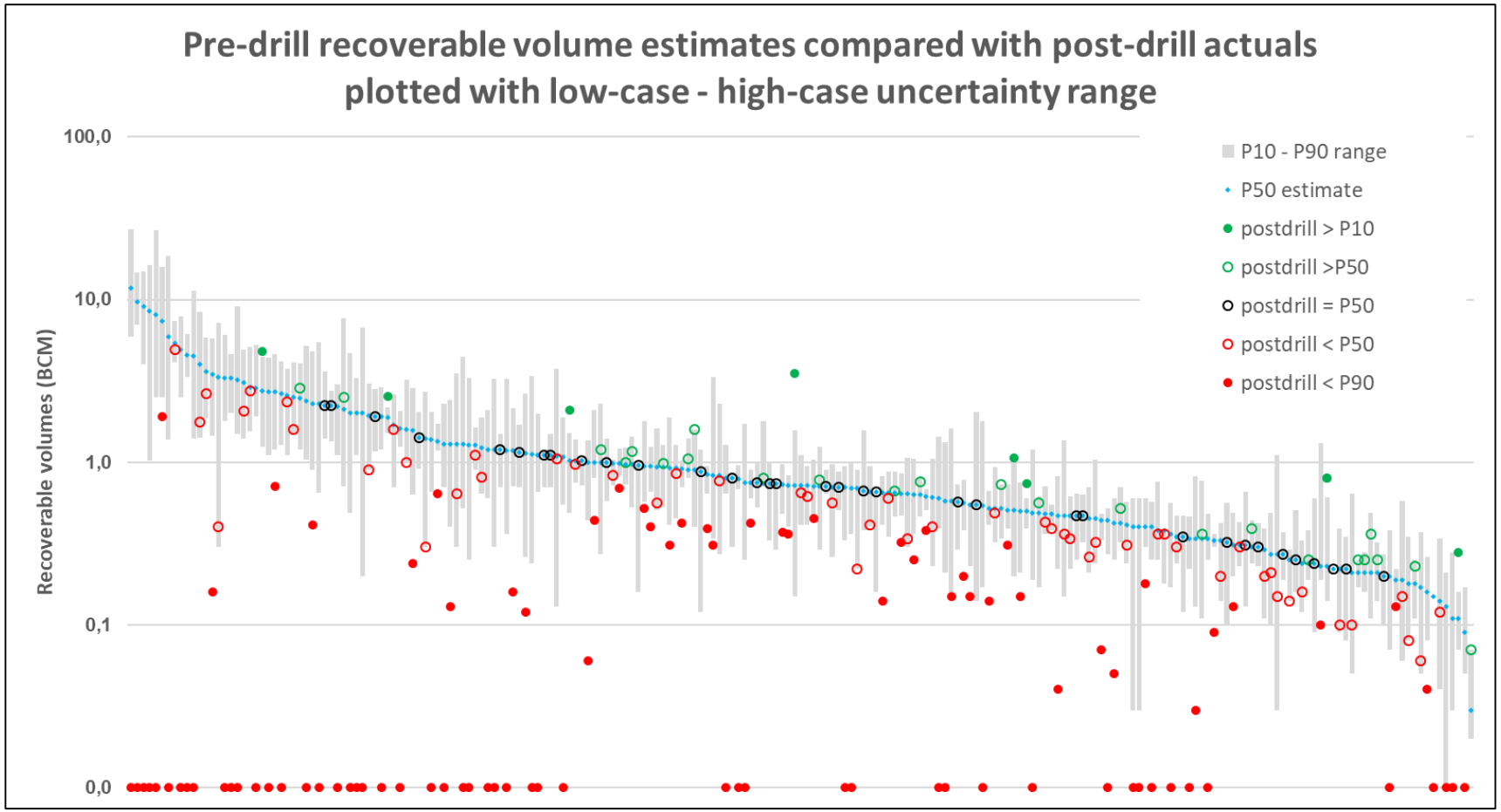
Saturation

Expansion factor

GIIP = GRV x N/G x Por x Sg x Bg

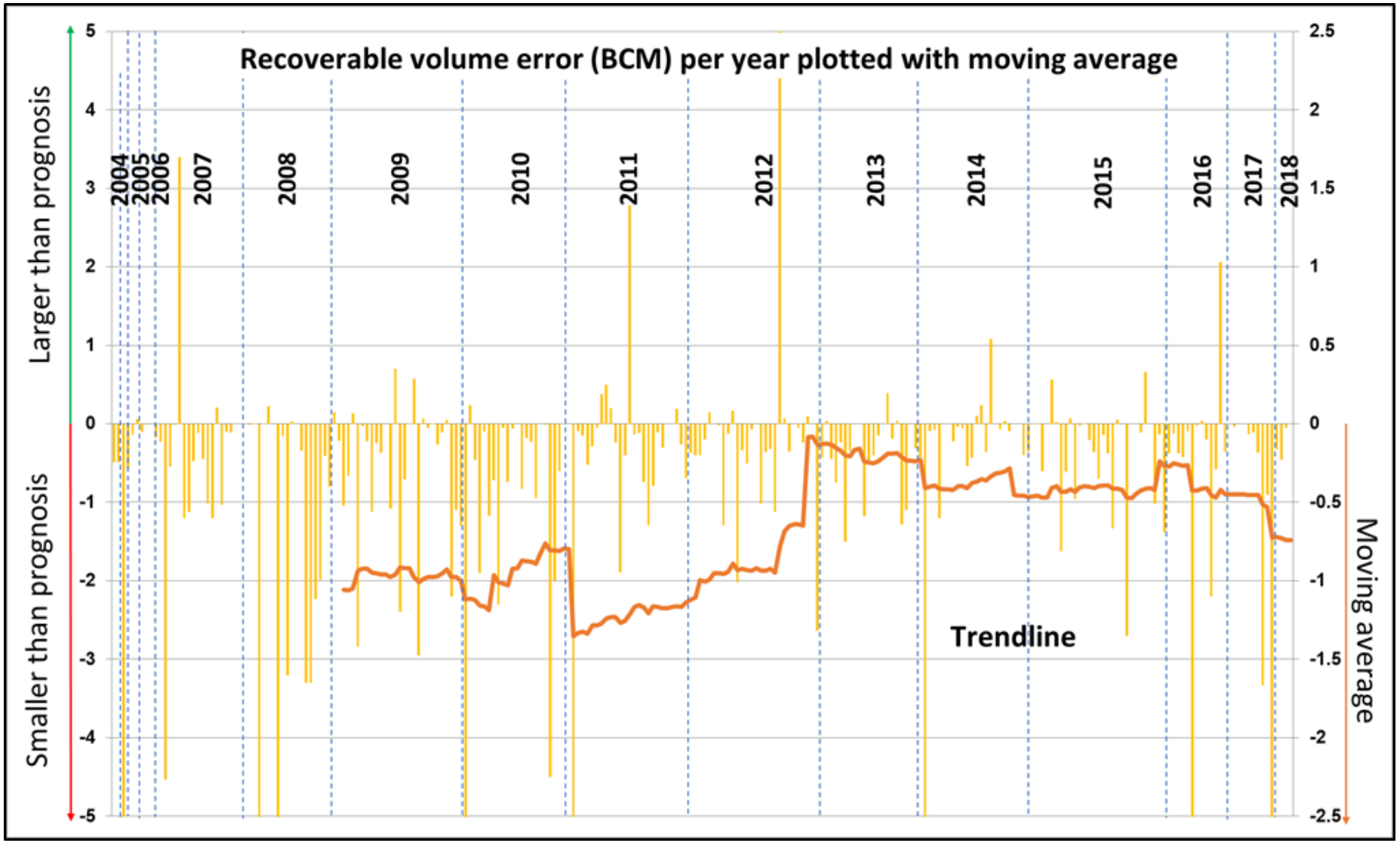
Based on multiple workflows incl. static models, dynamic models, welltests…

Volumes prediction performance: lookback



- 215 wells from NL
- 149 wells (69%) < P50 (including dry holes)
- Volume delivery: 58% of Expectation cumulative

Volume prognosis error over time

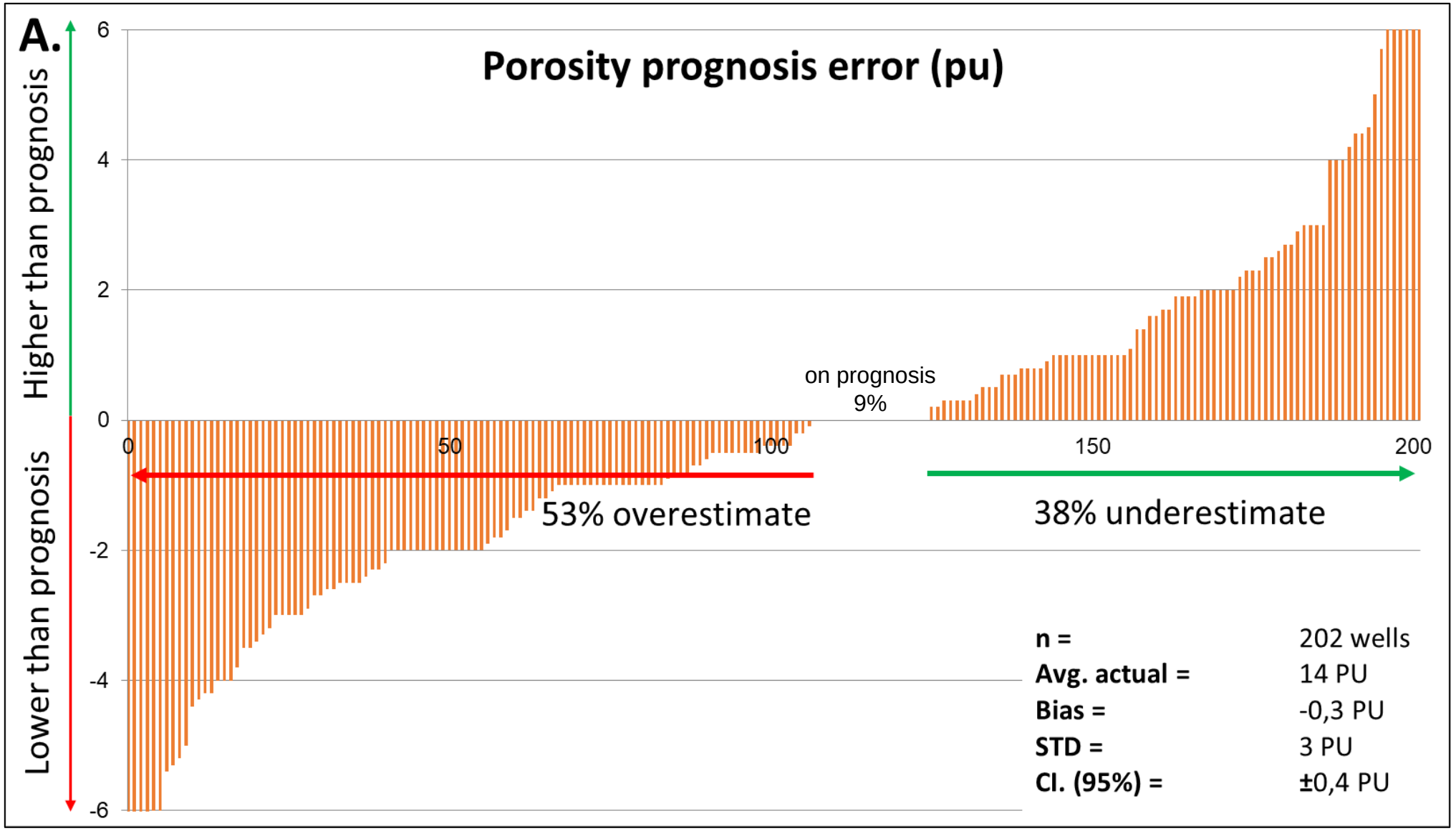


Recoverable volume prognosis error plot per year with trendline.
(averaging window: 50 wells)

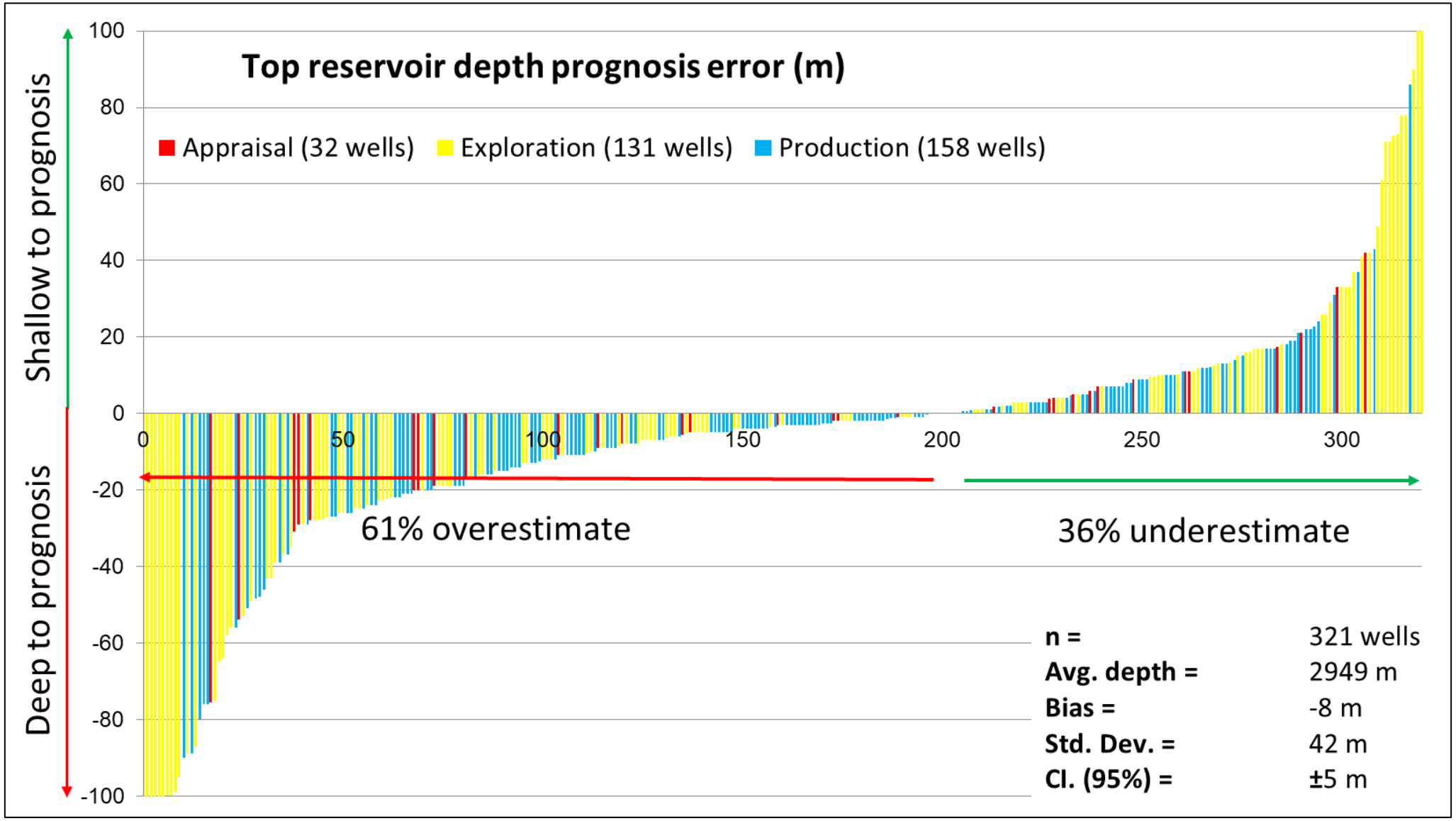
Key parameters affecting volumetric estimates

- Porosity
- Reservoir depth
- Gas-water contact
- Column height
- Water saturation
- Net to Gross

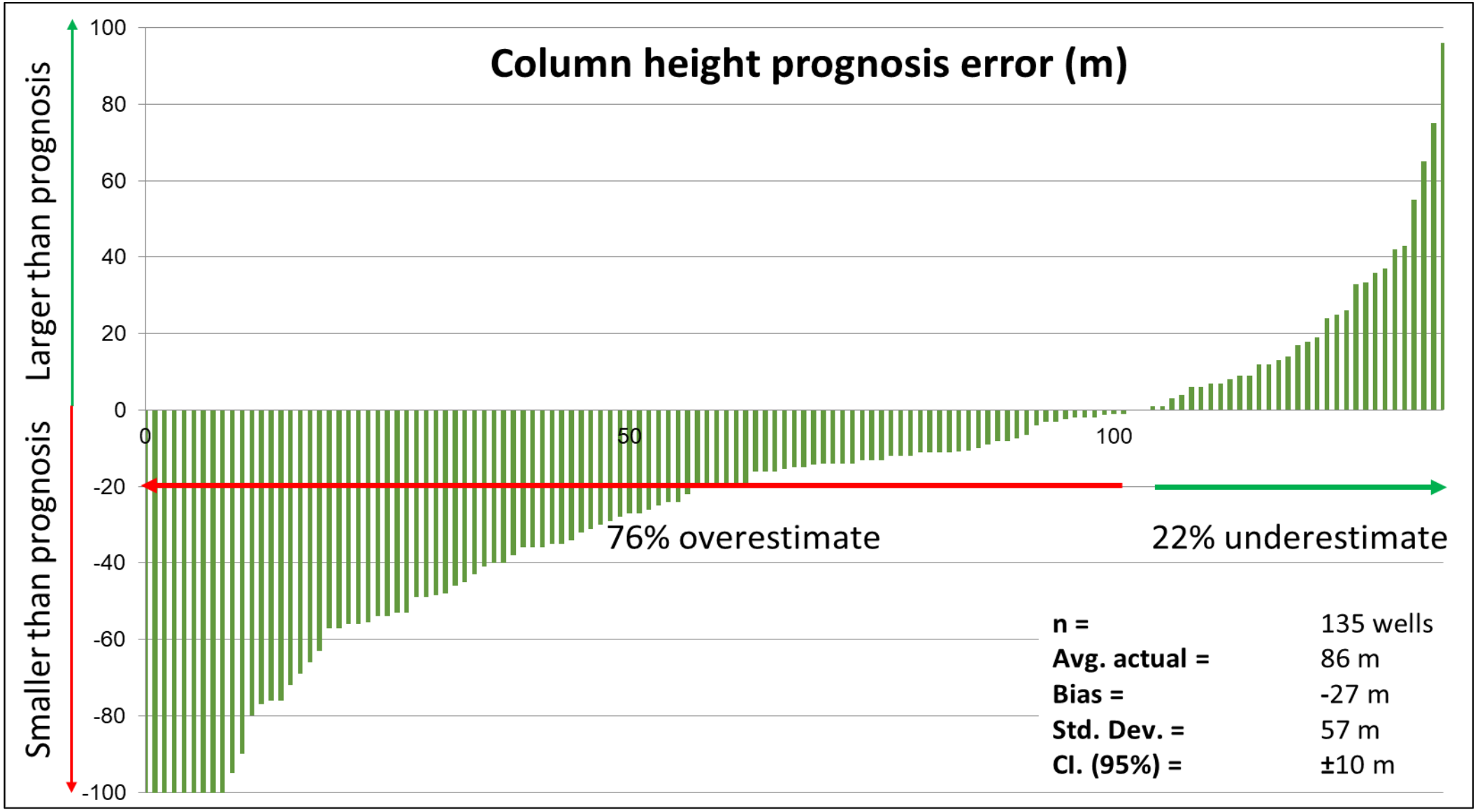
Porosity


A.
Porosity prognosis error (pu)
Higher than prognosis
Lower than prognosis
6
4
2
0
-2
-4
-6
0
50
100
150
200
on prognosis
9%
53% overestimate
38% underestimate
n = 202 wells
Avg. actual = 14 PU
Bias = -0,3 PU
STD = 3 PU
CI. (95%) = ±0,4 PU

Top reservoir depth

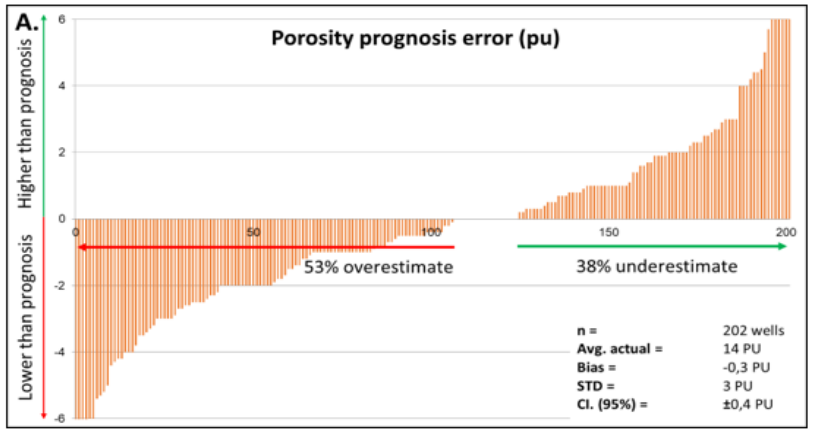


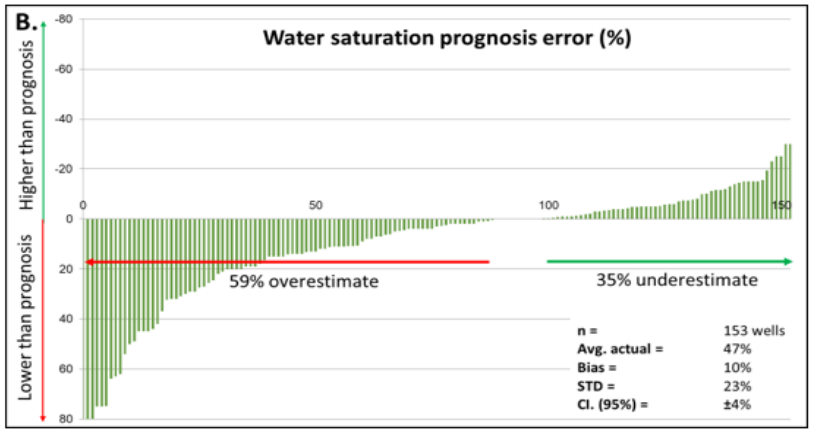
Column height

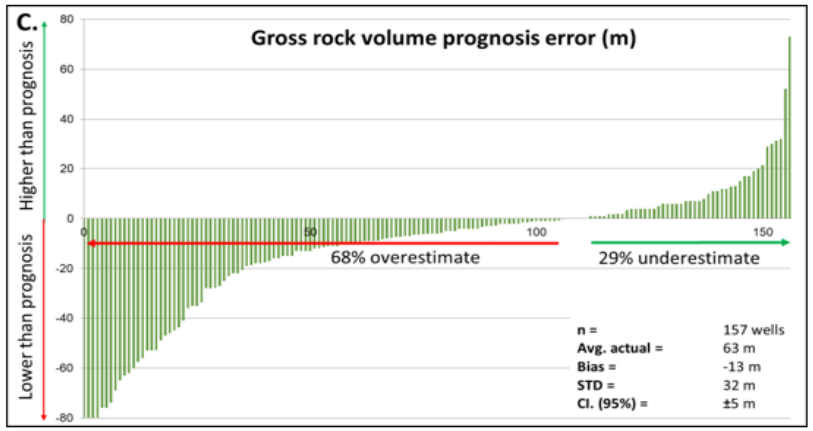


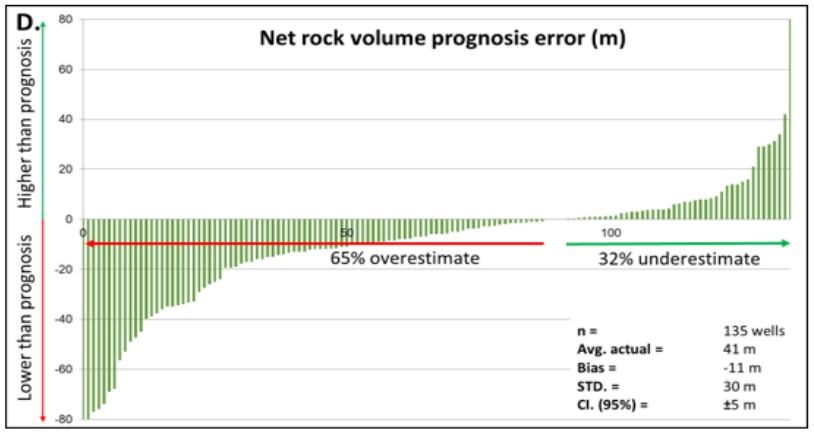
Key parameters affecting volumetric estimates

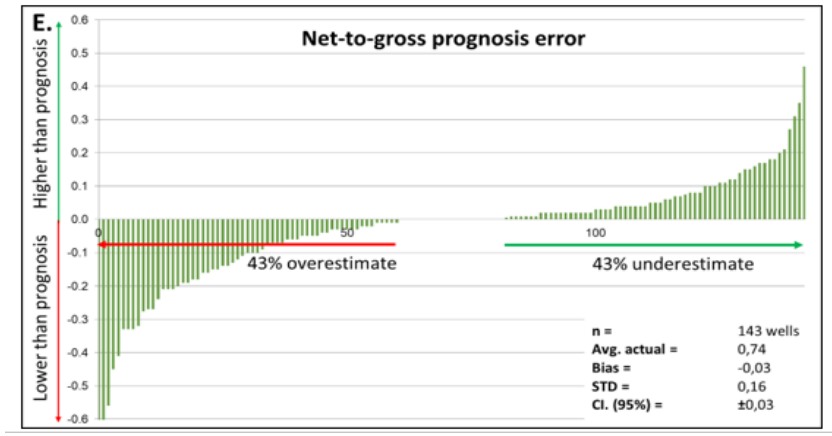
Bias to overpromise everywhere,
but is it significant?

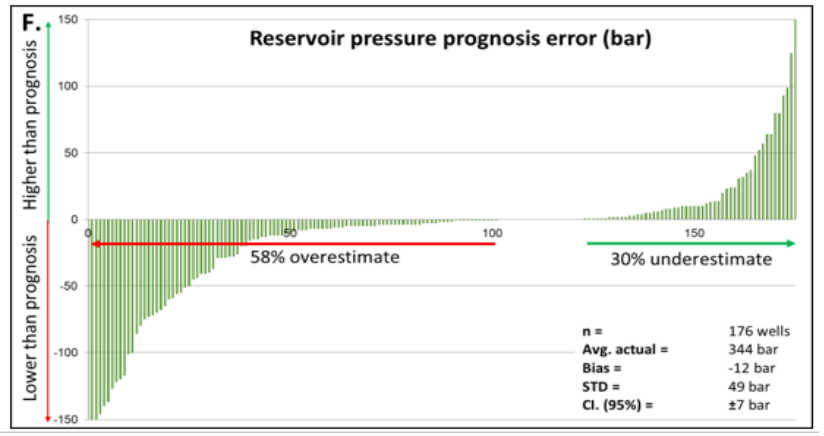












Bias: statistical significance

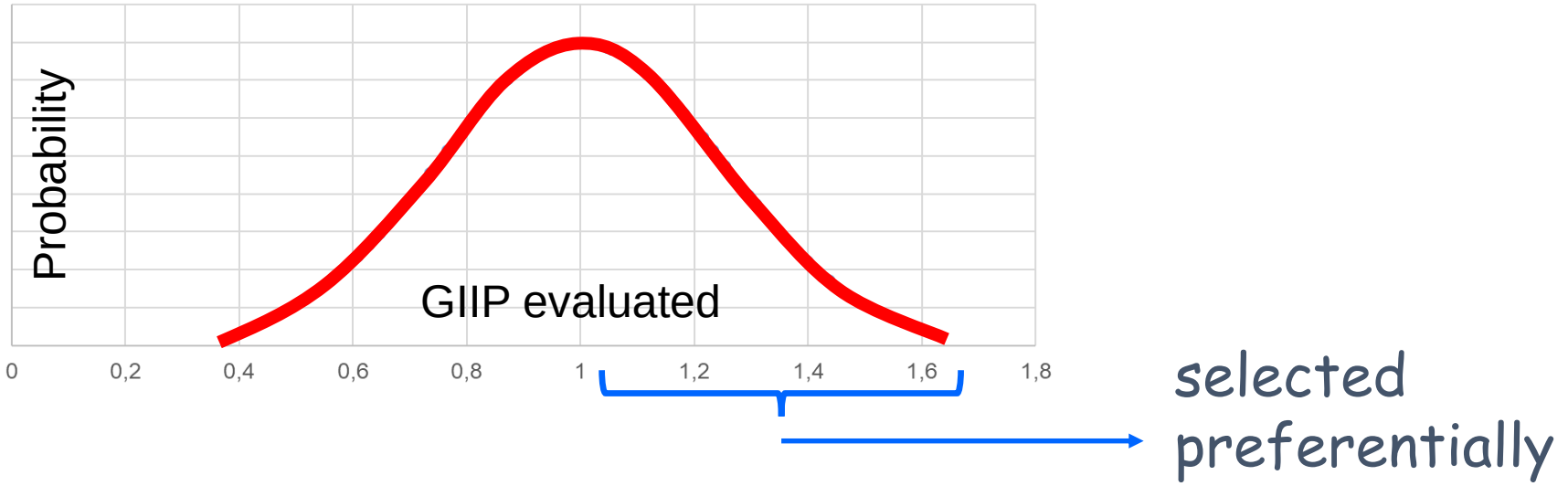
Parameter	Overprediction	T-test* result
Sw	21%	Significant
PORO	2%	Not significant
GRV	18%	Significant
NRV	26%	Significant
N/G	2%	Barely significant
Pressure	4%	Significant

GRV and Sw most biased parameters

**Two tail paired T-test after Fosfold et al., 2000*

Selection Bias: the concept

1. *Hypothetical* prospect portfolio: 50 prospects: each containing 1 bcm GIIP.
2. Explorers have *imperfect data* to asses prospect volumes and build portfolio.



3. Portfolio ranked in order of *attractiveness* (volume is key driver!)
4. Only *most* “attractive” *part* of portfolio drilled.

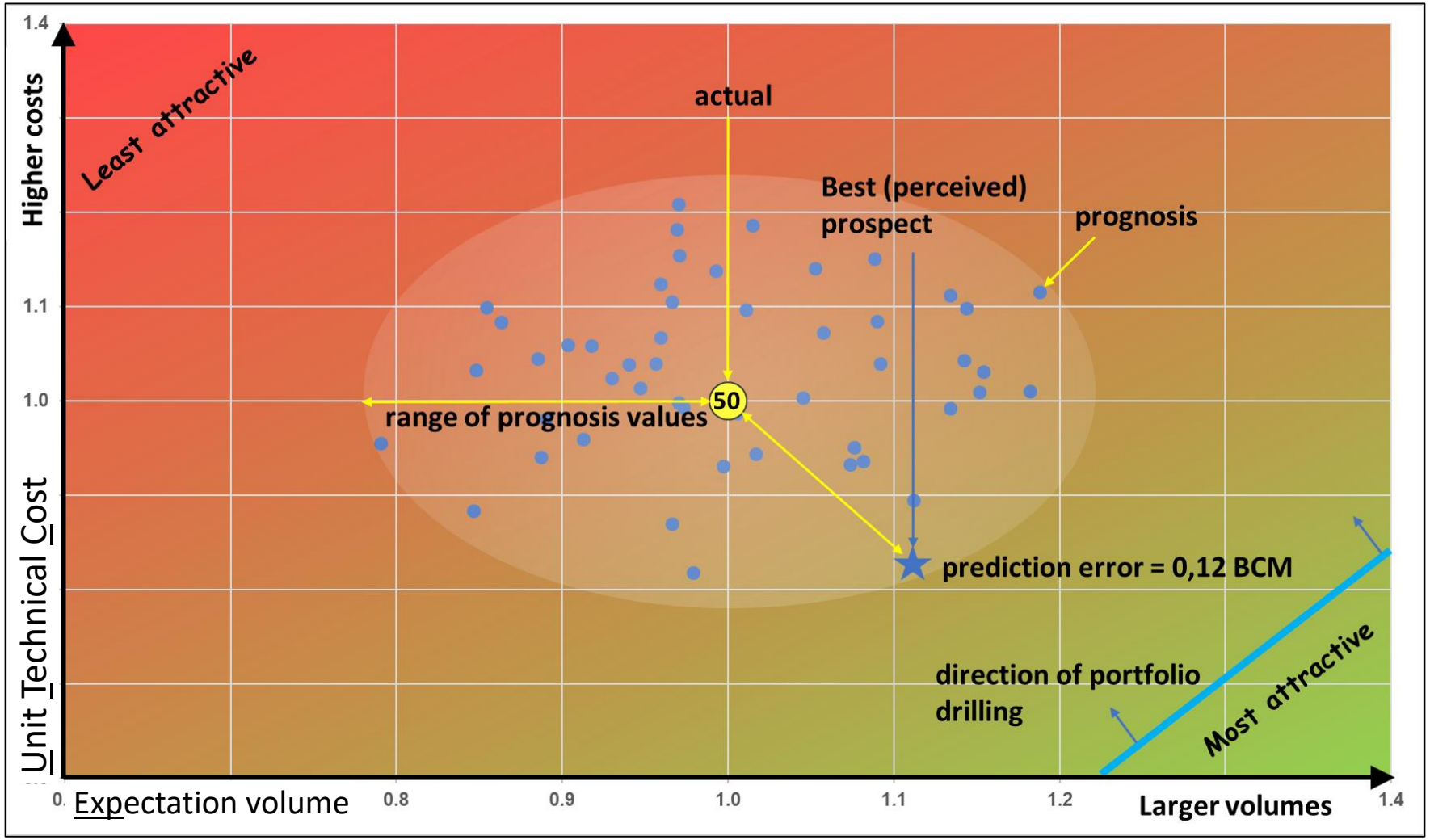
Synthetic portfolio modelling

- Create synthetic portfolio of prospects
- Each prospect characterized by two parameters:
  - EXP (risked UR)
  - Unit Technical Cost (UTC)
- Prospect value* determined by EXP & UTC
- Prospect ranking based on highest value
- Only part of portfolio being tested

**Prospect value ~ EXP * (gas price – UTC)*

Synthetic portfolio modelling 1

each prospect characterised by volume (~EXP) and cost (~UTC)

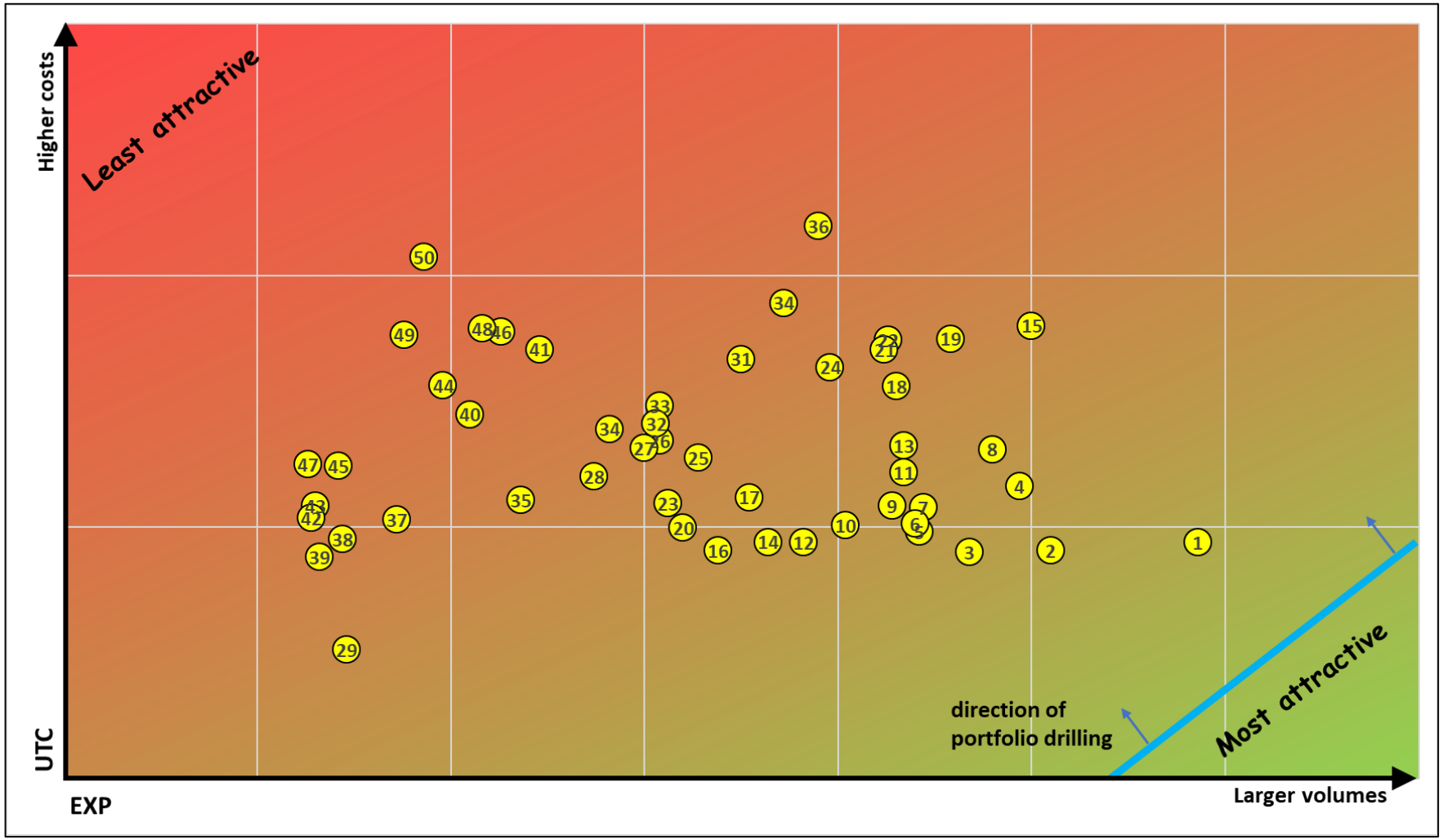


- 50 equivalent prospects with EXP =1 and UTC = 1
- noise in data (STD= 0.1)
- Prospect value prognoses stochastically modelled
- Drill top 50% ->
- Act. = 25 BCM
- Prog. = 27 BCM

➡ 2 BCM overpromise (bias~ 8%)

Synthetic portfolio modelling 2a

each prospect characterised by volume (~EXP) and cost (~UTC)



50 prospects with varying EXP and UTC

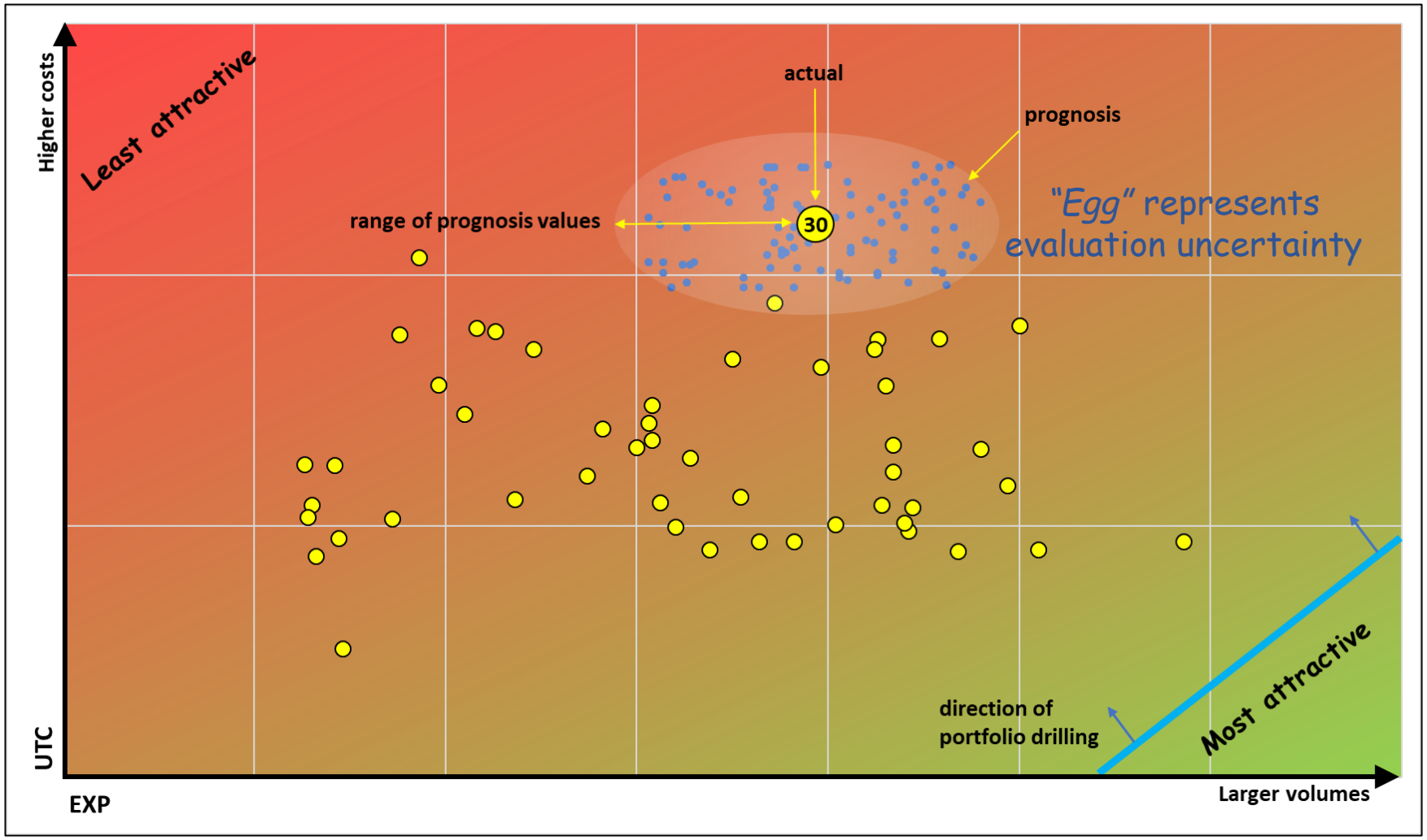
Realisation values

generated stochastically with mean EXP=1, mean UTC=1

Numbered according to ranking on *prospect value*

Synthetic portfolio modelling 2b

each prospect characterised by volume (~EXP) and cost (~UTC)



50 prospects with varying EXP and UTC

Realisation values

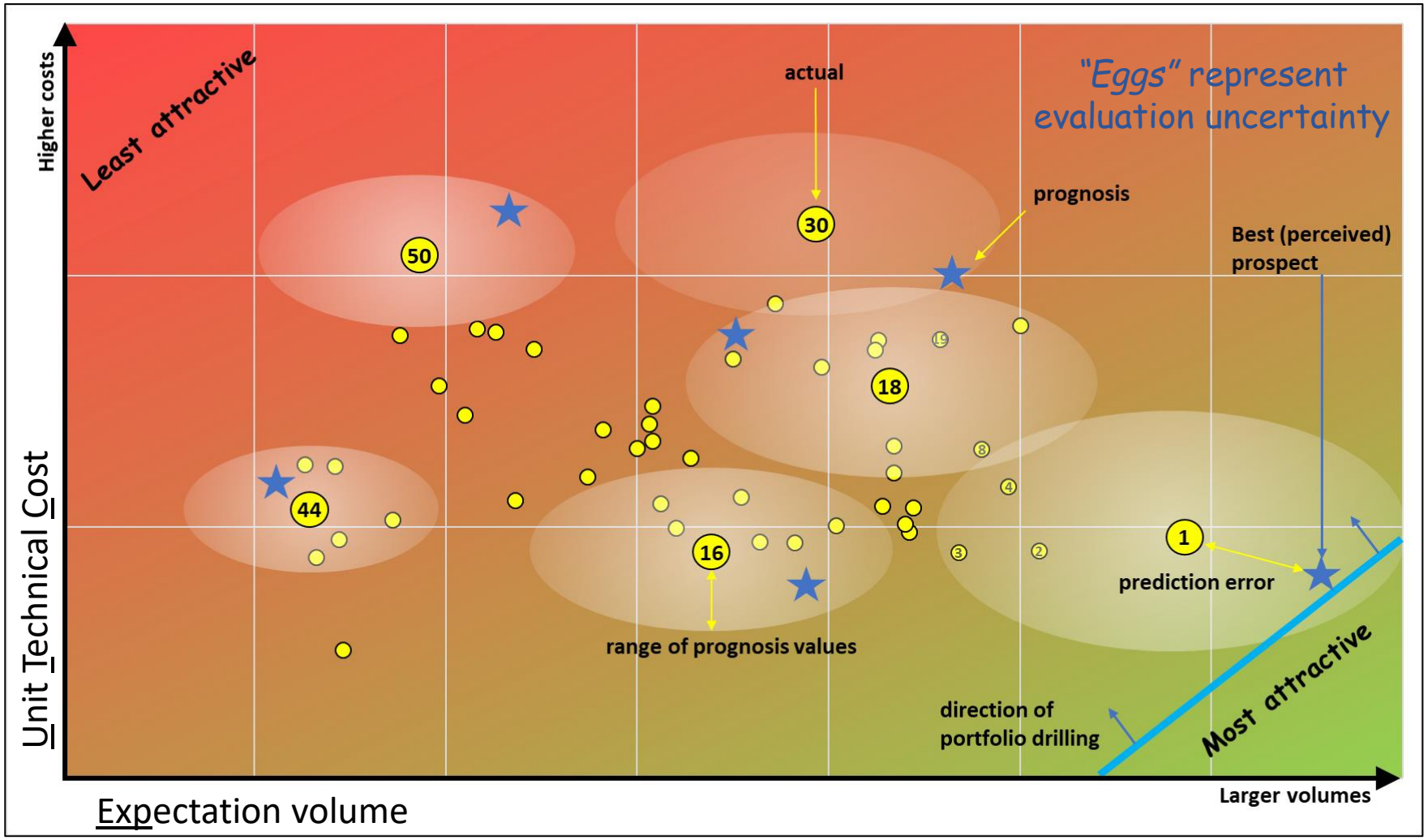
generated stochastically with mean EXP=1, mean UTC=1

Prognosis values

generated stochastically around realisation

Synthetic portfolio modelling 2c

each prospect characterised by volume (~EXP) and cost (~UTC)



50 prospects with varying EXP and UTC

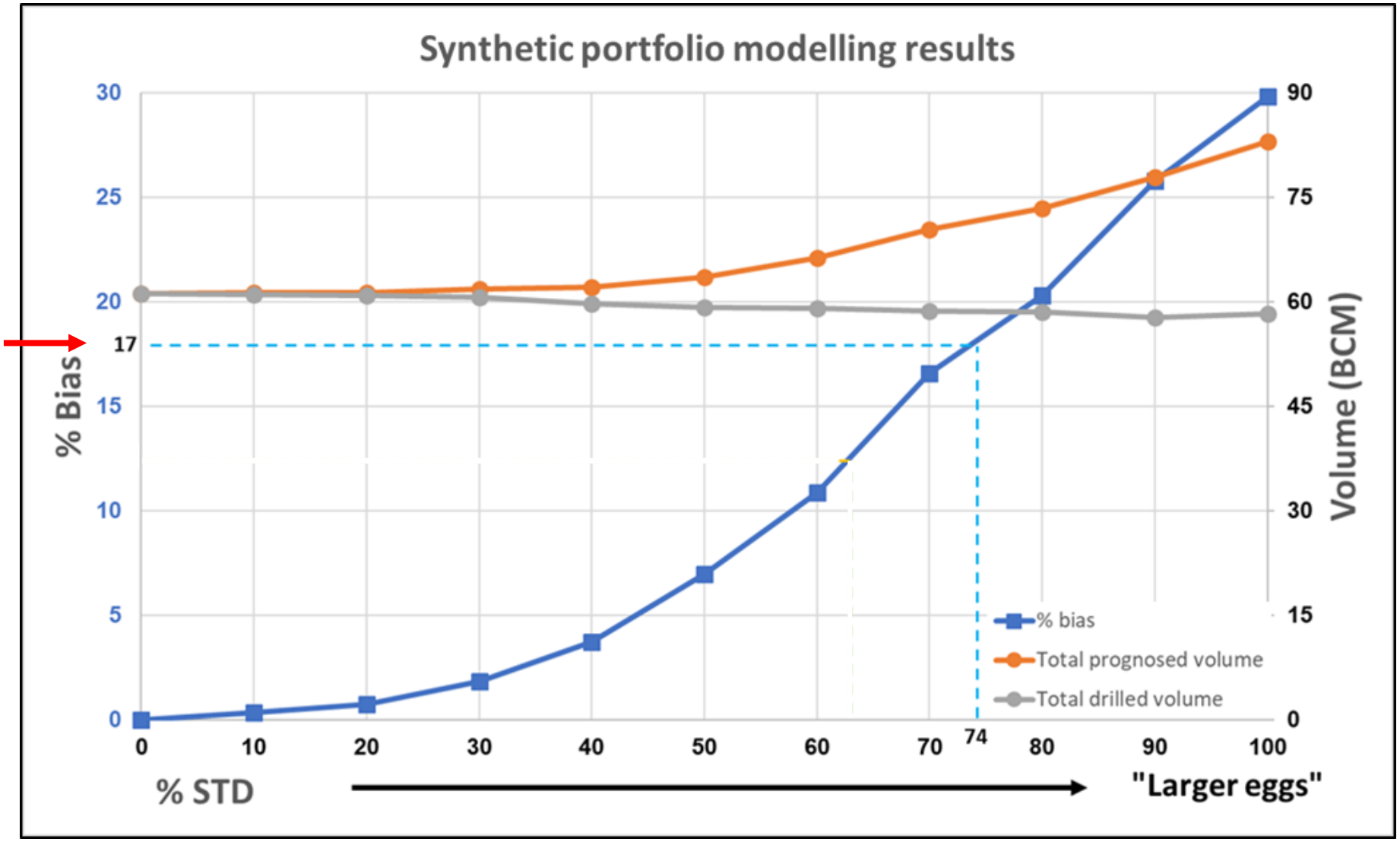
Stochastic assessment for prognosis

Ranking based on **prognosis** value

(*not actual value!*)

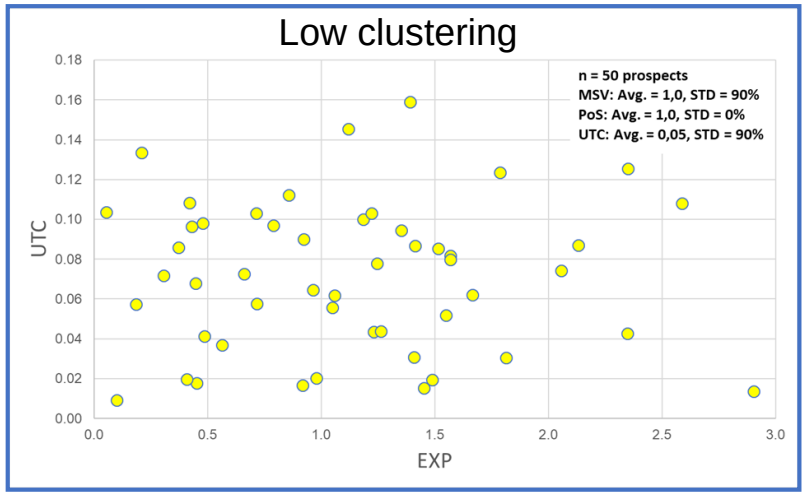
Selection Bias results

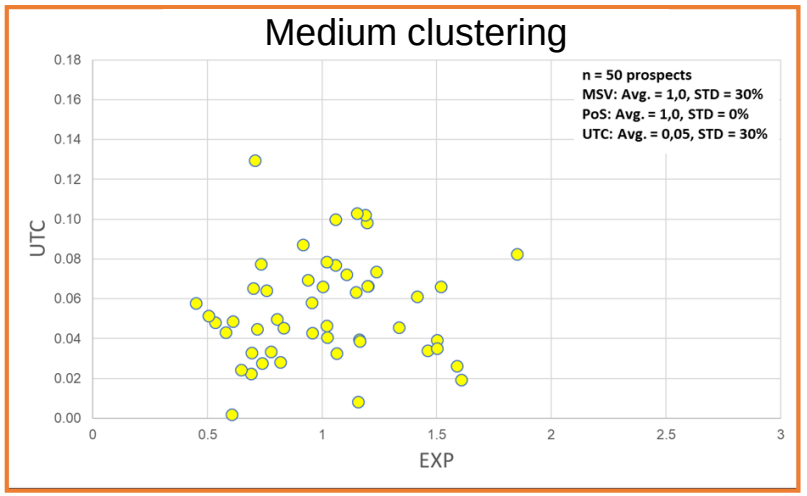
17% Selection bias with given assumptions

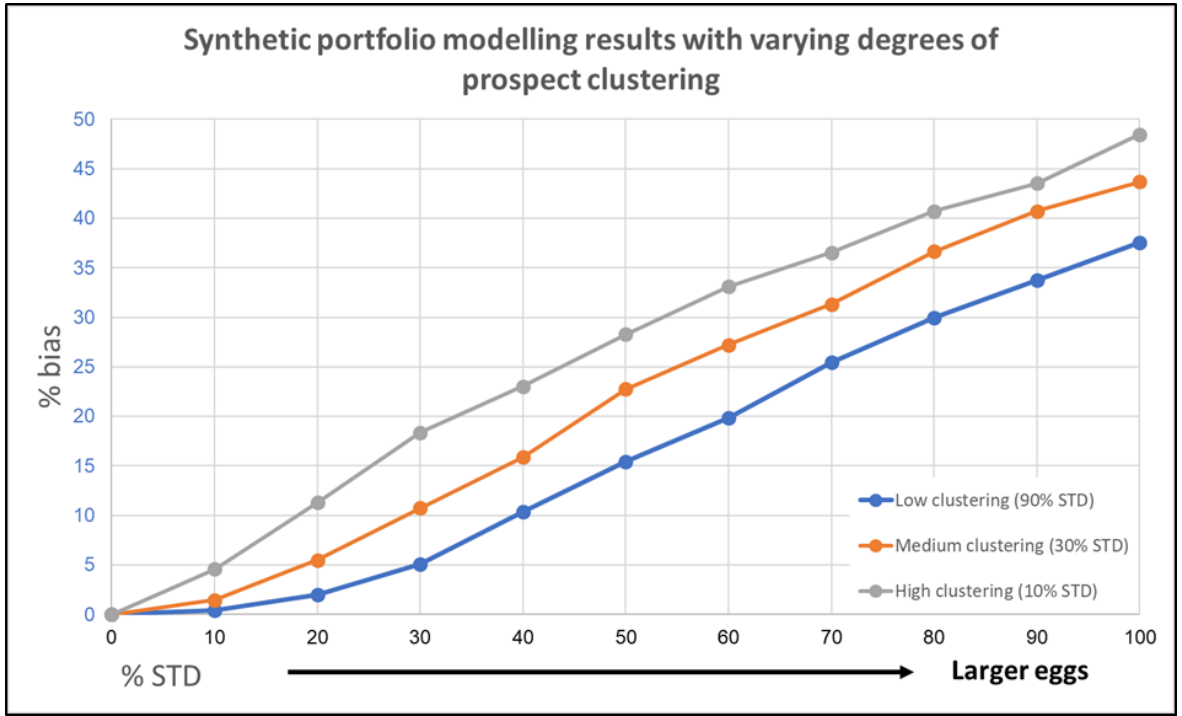


based on 100 simulated synthetic portfolios

Synthetic portfolio modelling: **Portfolio clustering**







high clustering
&
high uncertainty
can lead to > 40% bias!

Conclusions

- Well look-back analysis reveals significant volume prediction bias. Delivery 58% only.
- Prediction bias can have multiple causes: e.g. Tool Bias, Cognitive Bias and Selection Bias
- Prediction bias can be modelled based on the concepts from selection bias
- Biased predictions are unavoidable where sampling (drilling) is not random
- More mature portfolios lead to increased selection bias
- Predictions in other businesses (e.g. geothermal) are also expected to show selection bias especially when ranking is based on uncertain subsurface parameters (e.g. permeability)
- Don’t count on luck; T.I.N.A. for thorough technical work!

Questions

Acknowledgements:

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More details:

Drilling Portfolio Performance
and the role of Survival Bias in volume estimates
EAGE Annual Conference 8-11 Dec 2020
(paper 1058; on www.earthdoc.org)