Technical Session Agenda
2016 SPEE Annual Meeting

Tuesday, June 7, 2016 **2016 SPEE Technical Session 2** **Salon I/II**

10:30 AM	**Risky Business: Managing Uncertainty in Upstream Decision-Making**	Tyler Schlosser

BIOGRAPHY
Tyler Schlosser – GLJ Petroleum Consultants

Tyler is GLJ's Director of Commodities Research, focusing on economic modeling, risk analysis, commodity pricing and business development. Tyler is responsible for generating GLJ's commodity price forecasts and modeling fiscal regimes across a broad range of international jurisdictions. With expertise in unconventional evaluations, probabilistic modeling and machine learning techniques, Tyler routinely tackles unique and complex problems for GLJ's clients.

RISKY BUSINESS: MANAGING UNCERTAINTY IN UPSTREAM DECISION-MAKING

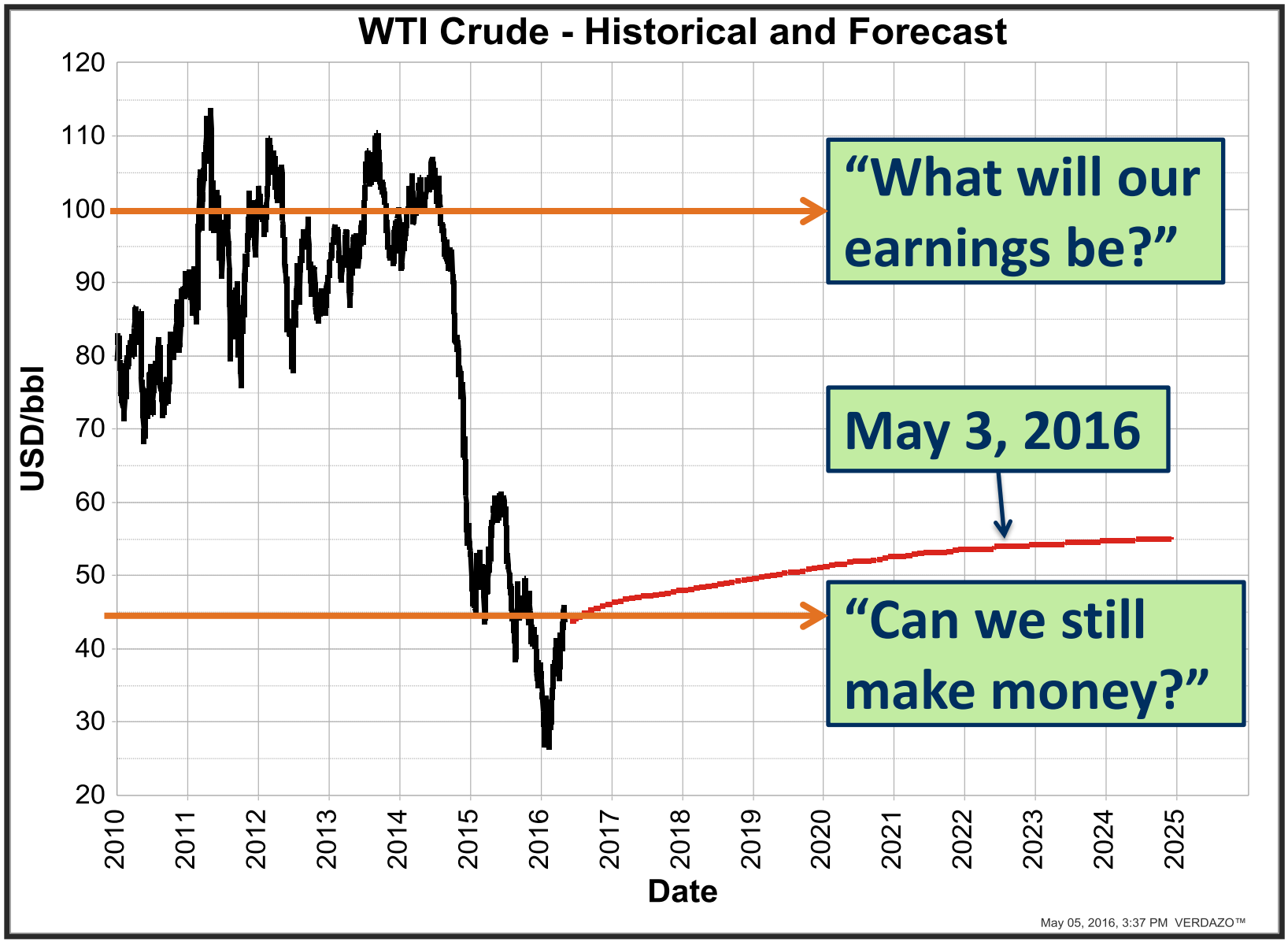
Tyler Schlosser, P.Eng.

June 2016

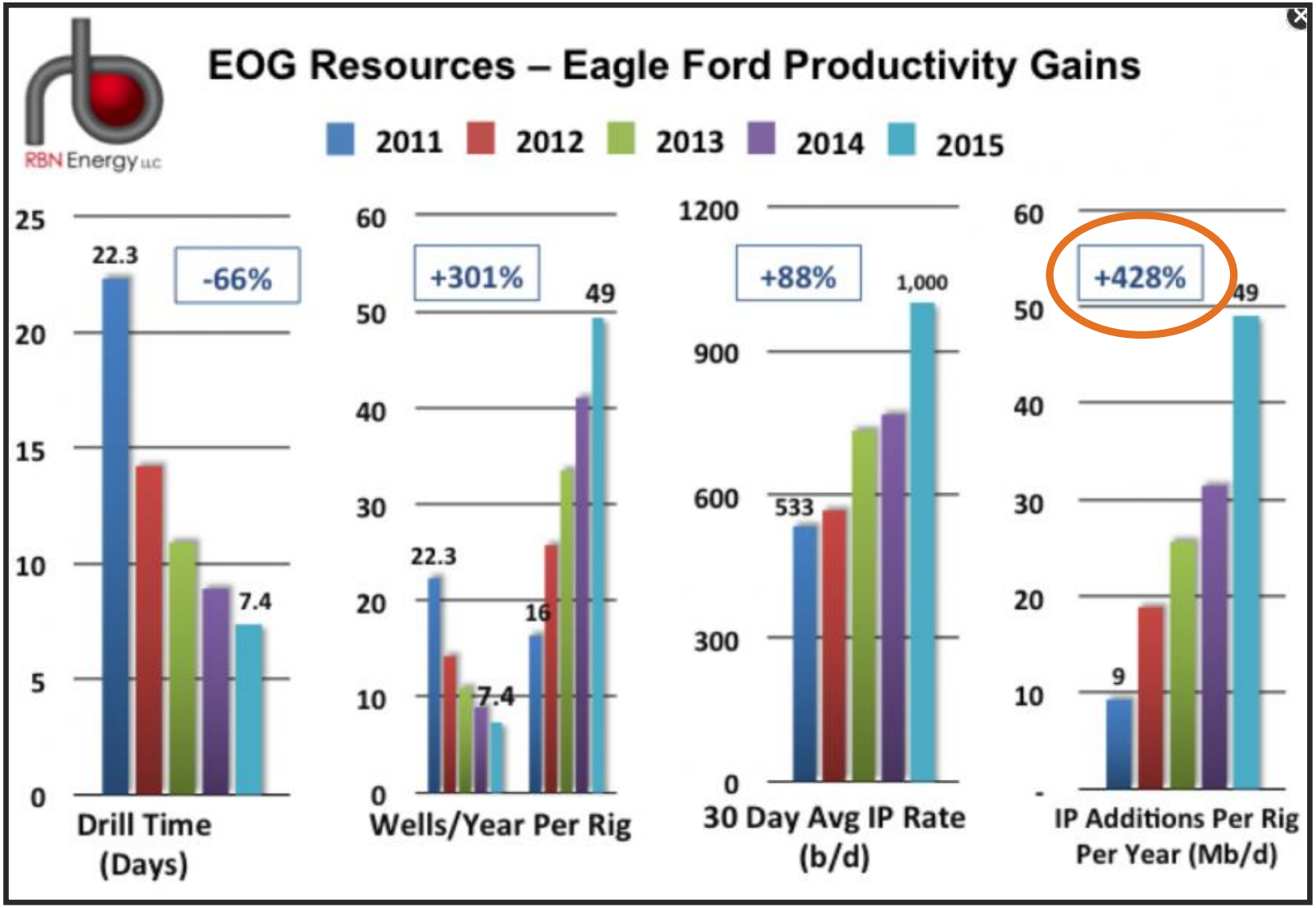
WHAT SMART PEOPLE SAY ABOUT UNCERTAINTY

- "We must become more comfortable with probability and uncertainty."
  - Nate Silver (author and statistician, FiveThirtyEight.com)
- "Some people say, 'How can you live without knowing?' I do not know what they mean. I always live without knowing. That is easy. How you get to know is what I want to know."
  - Richard Feynman (Nobel prize-winning physicist)
- "The world is noisy and messy. You need to deal with the noise and uncertainty."
  - Daphne Koller (AI researcher, Stanford University)
- "Recognizing uncertainty is a sign of humility, and humility is just the ability or the willingness to learn."
  - Charlie Sheen (Two and a Half Men)

NAVIGATING OUR NEW REALITY



THE UPSTREAM INDUSTRY IS MORE ADAPTABLE THAN IT GETS CREDIT FOR

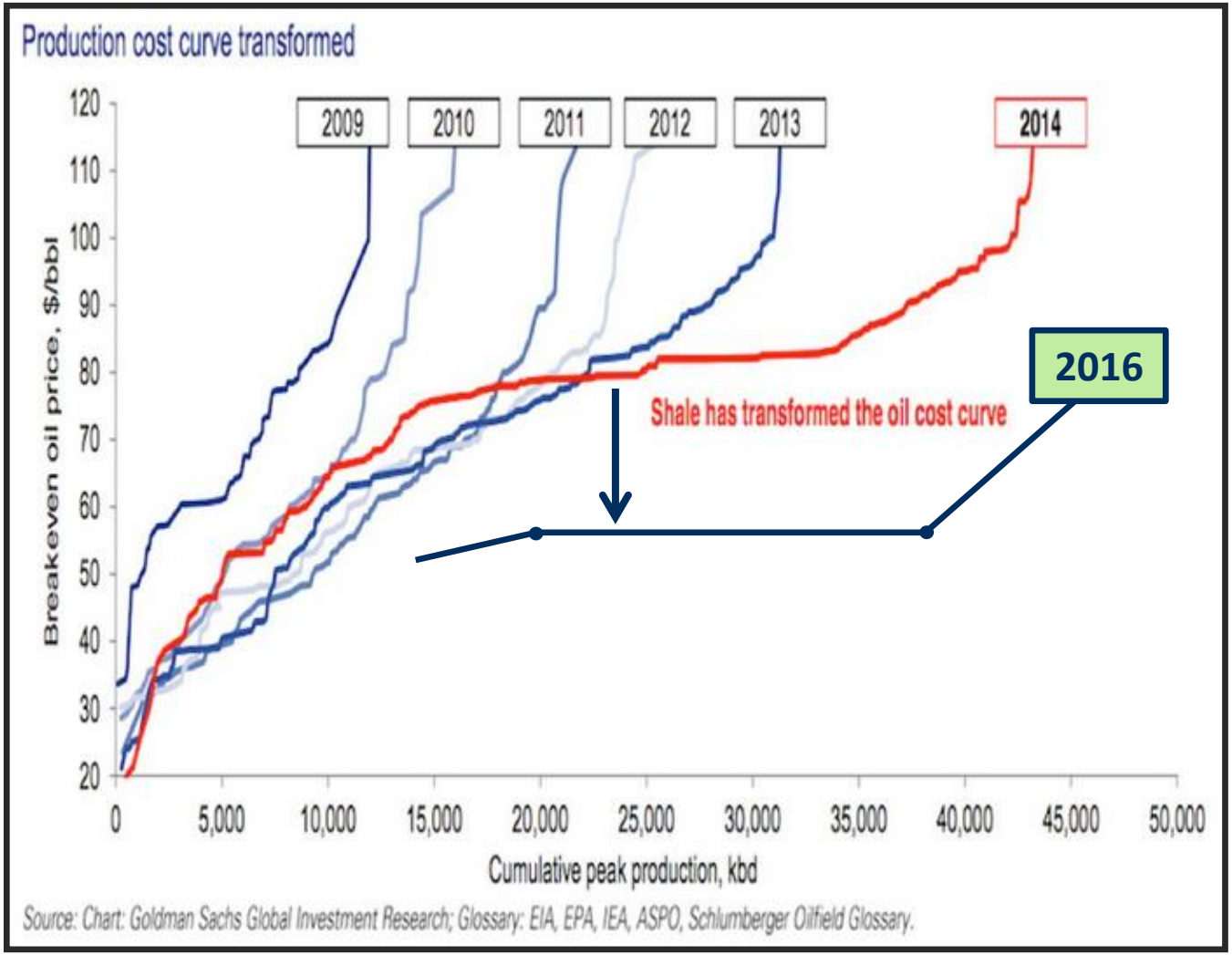


Source: RBN Energy, EOG

$55 IS THE NEW $80

- Technology
- Efficiency
- Cost deflation
- Quick payouts

High quality US shale acreage can sustain development at sub-$40 WTI



HOW CAN WE ACTIVELY MANAGE RISK?

- **Optimize allocation of finite capital**
  - Where can we spend the next dollar to receive maximum benefit?
- **Define "optimal"**
  - What are our criteria for success?
  - Are we only interested in maximizing the expected value?
  - Are we willing to give up some expected value to reduce our risk?
- **Understand a broad range of plausible outcomes**
  - Analyzing only the expected outcome ignores important information
  - What failure rate can we live with?
- **Understand correlated uncertainties**
  - Overall risk is greater when individual uncertainties are correlated than when they are independent

HOW CAN WE ANSWER THESE QUESTIONS? EXAMPLE PLAY: KERROBERT VIKING OIL

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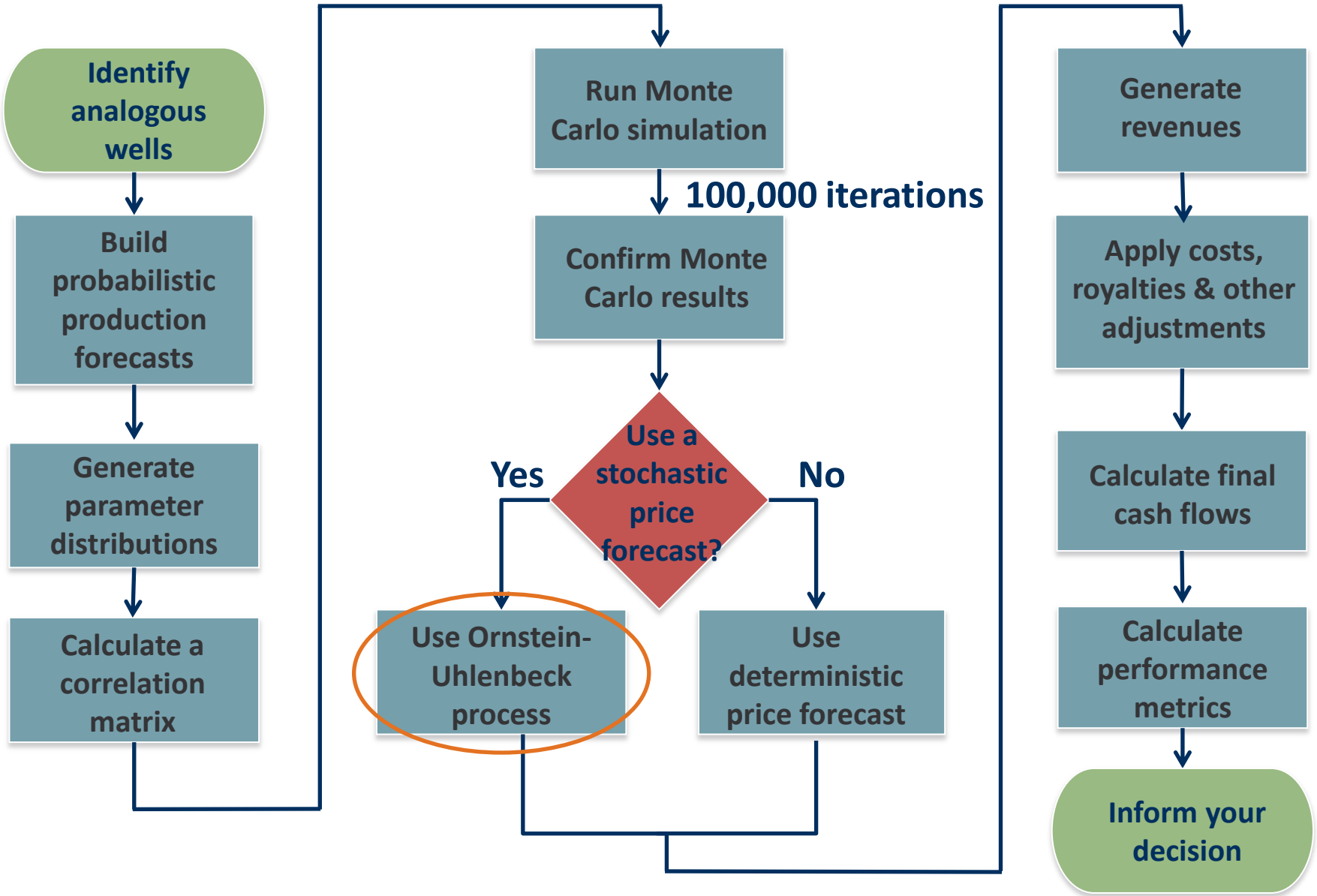
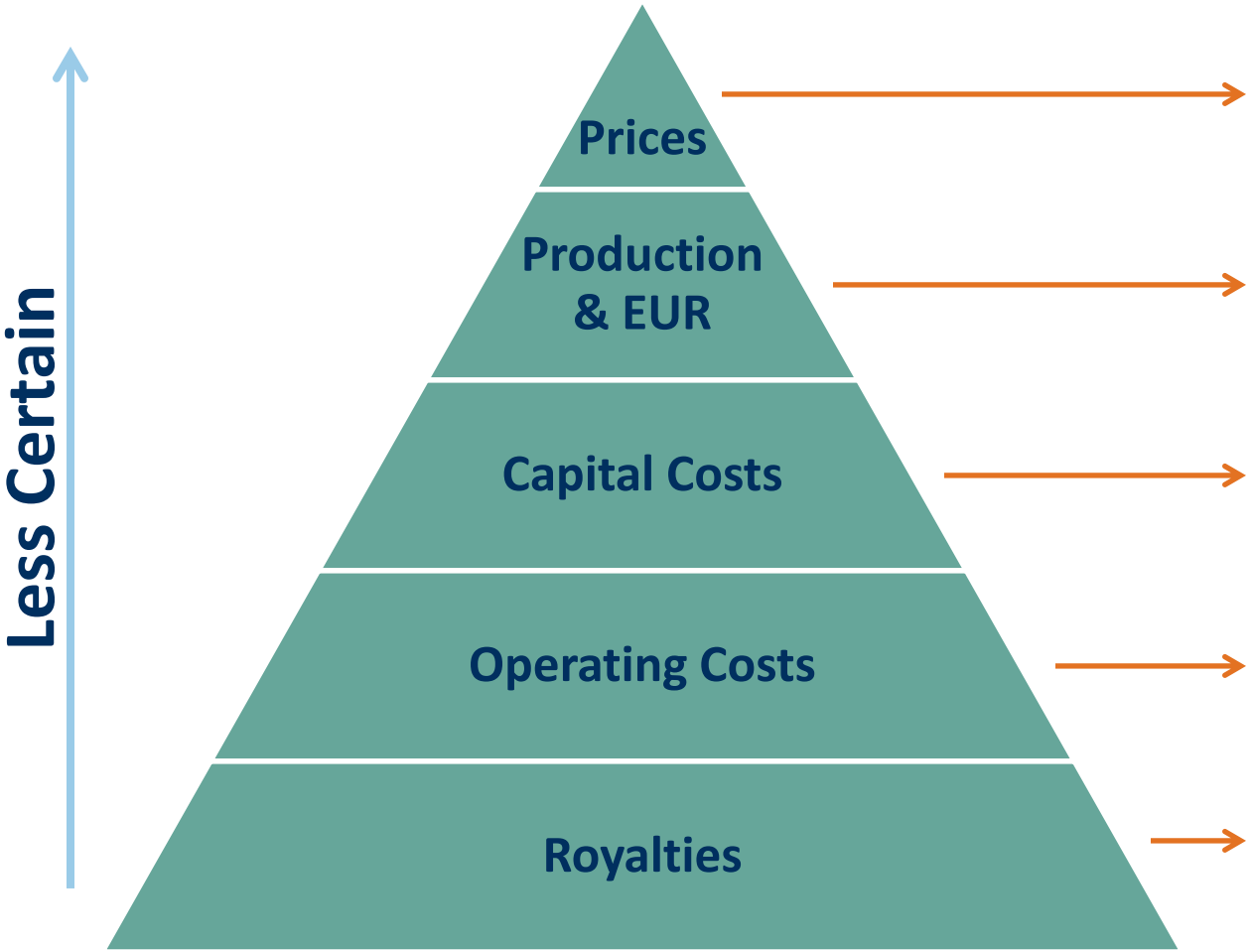
1. **What is the chance that WTI will average at least 60 USD/bbl in 2017?**
2. **What average 2017 WTI price are we 90% confident will be exceeded?**
3. **How likely is it that a single horizontal Kerrobert Viking well will pay out?**
4. **What is the chance of realizing a NPV_{10} greater than zero for a 10-well drilling program spread across the Kerrobert area?**
   - What if all 10 wells are drilled in the same section?
5. **How many wells would need to be drilled to be 50% confident of a PI_{10} greater than 1.2?**
   - What if all wells are drilled within two miles of each other?

PROBABILISTIC ANALYSIS WORKFLOW



RANKING UNCERTAINTY

Components of a Half-Cycle Economic Analysis



- Market prices are hard to predict
- Normally predictable to ±70% with 95% confidence one year out
- Hedging can improve certainty

- Well performance
- Operational issues
- Economic factors can limit

- Usually predictable within 15%
- Uncertainty largely tied to success/failure and experimentation

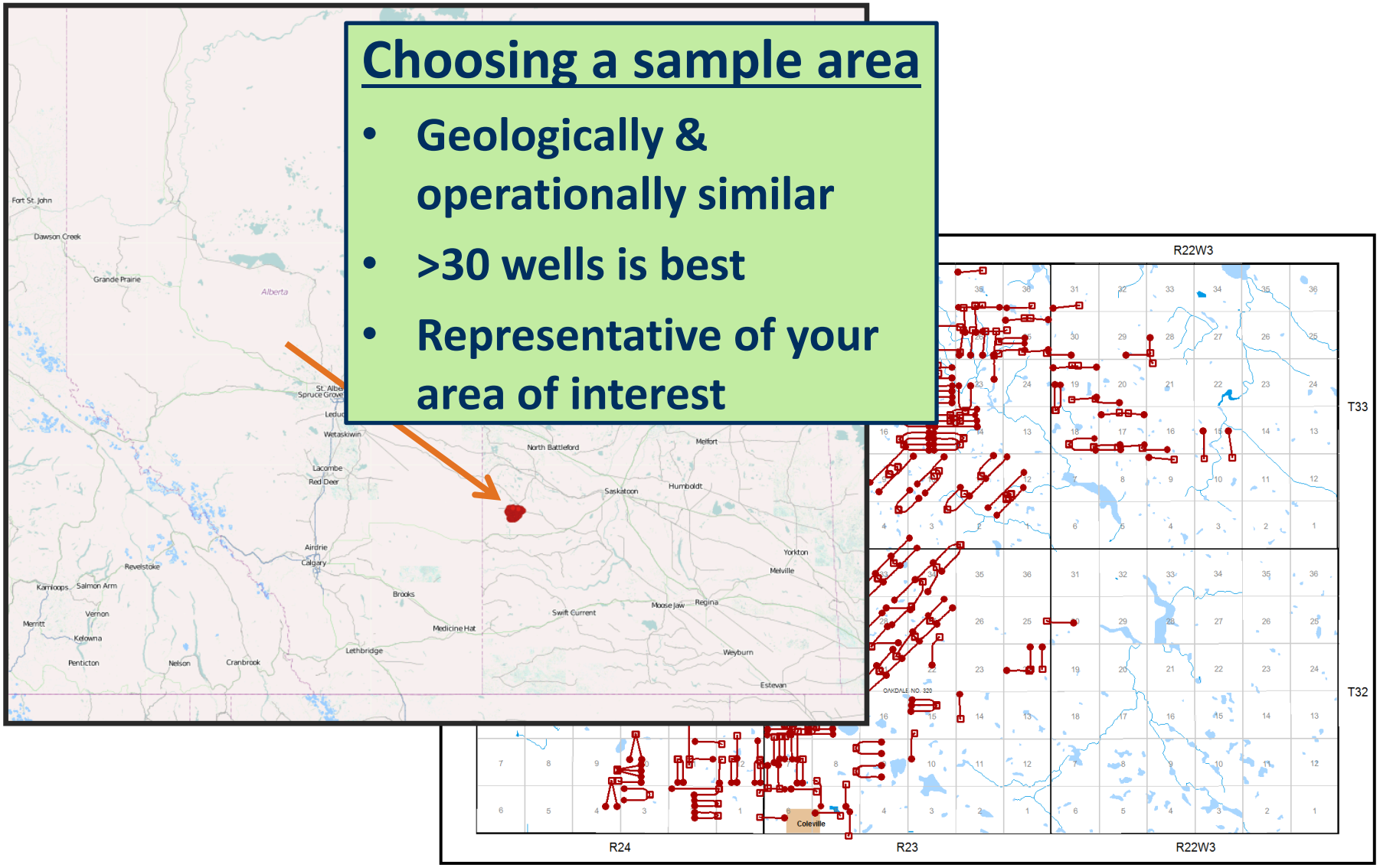
- Transportation bottlenecks
- Line pressures
- Unexpected issues, maintenance
- Competition, partnerships

- Long term uncertainty in regulatory framework
- Short term is usually quite certain

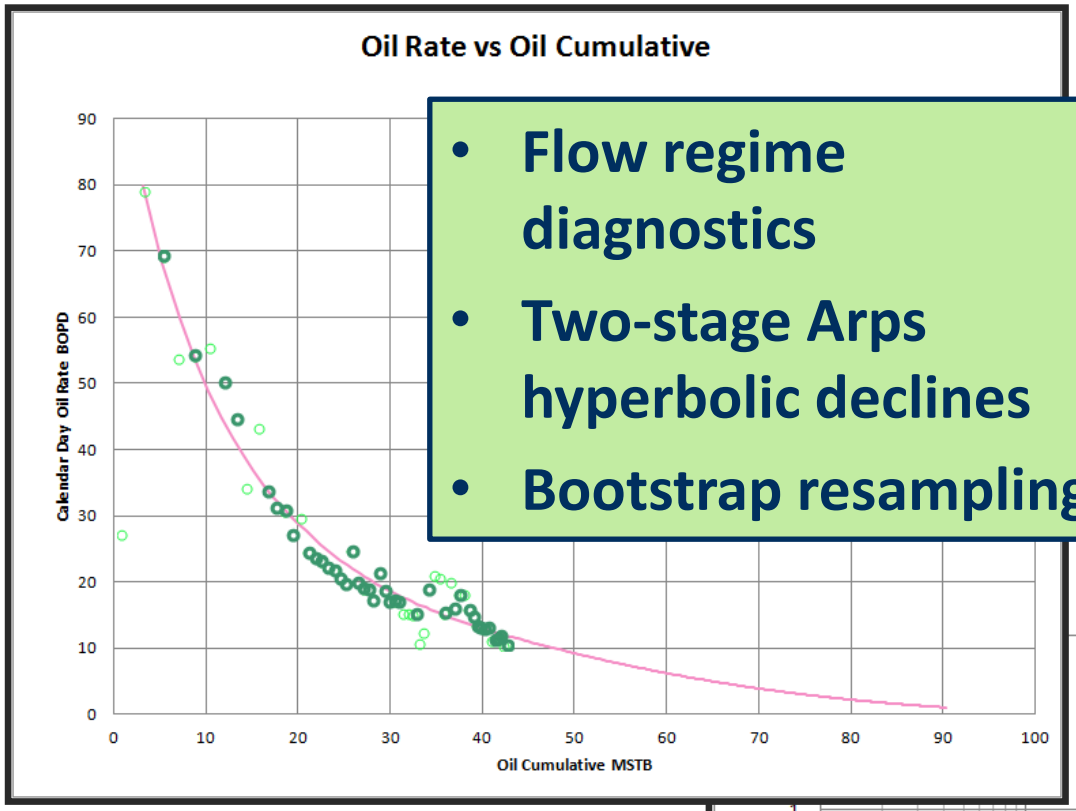
SAMPLE AREA – KERROBERT VIKING

Choosing a sample area

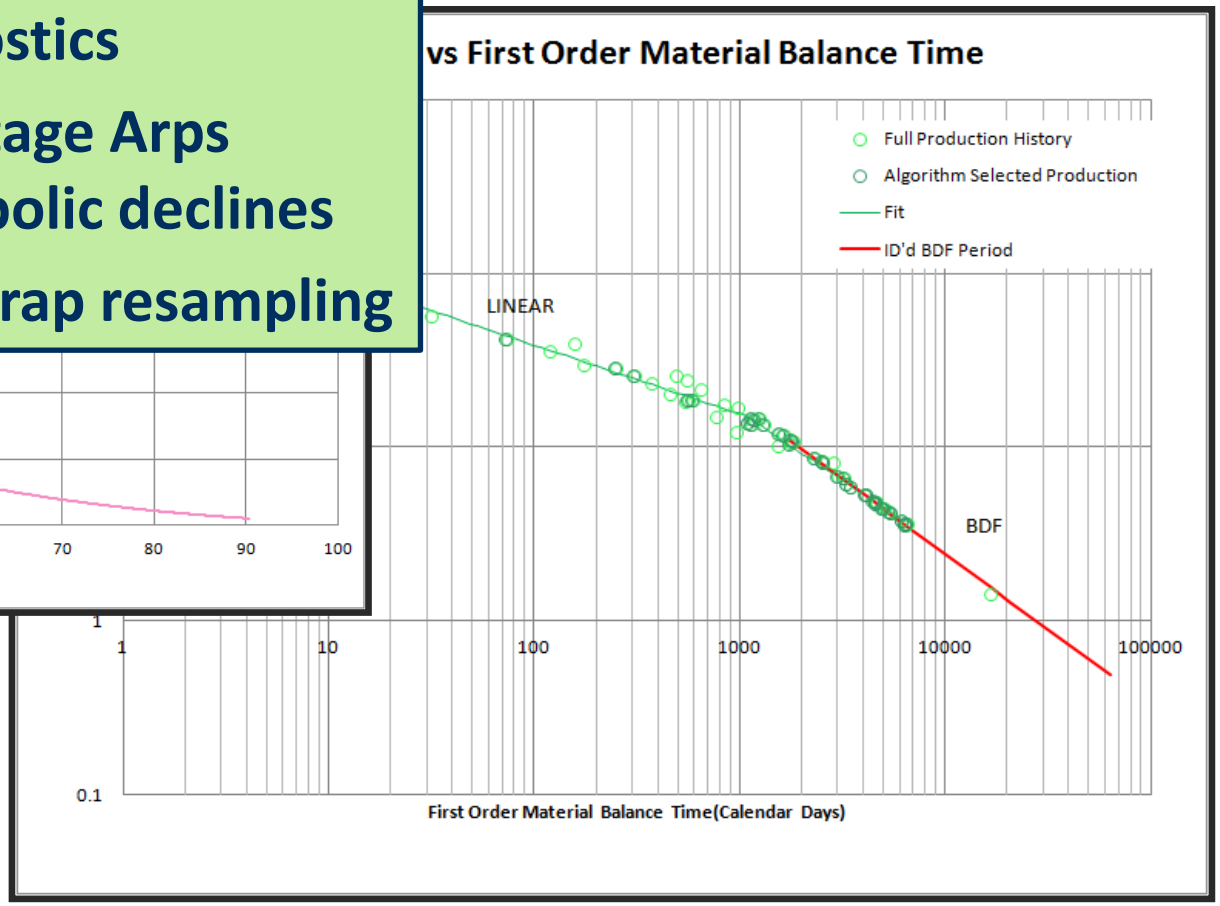
- Geologically & operationally similar
- >30 wells is best
- Representative of your area of interest



PROBABILISTIC PRODUCTION FORECASTING



- Flow regime diagnostics
- Two-stage Arps hyperbolic declines
- Bootstrap resampling



MOST RELATIONSHIPS IN RESOURCE ANALYSIS ARE NONLINEAR

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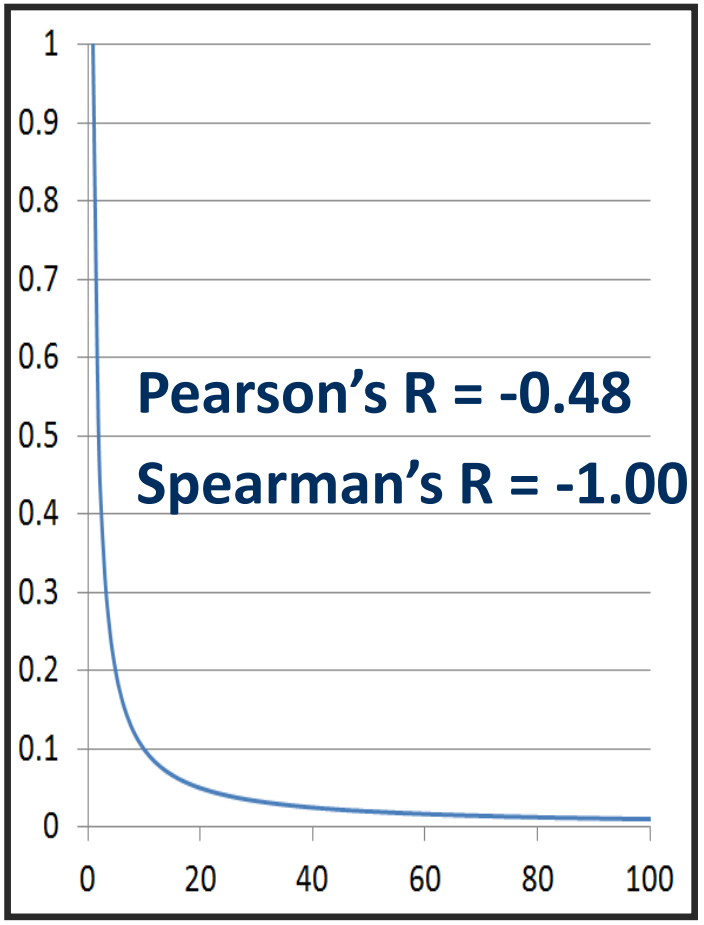
Spearman's Rank Correlation vs. Pearson's Correlation

Pearson's Correlation

- Assumes constant variance
- Tests fit to straight line
- Is the 'R' in the familiar 'R^2'

Spearman's Rank Correlation

- Is the linear correlation of ranks
- Better for nonlinear relationships
- Less sensitive to extreme outliers



DECLINE CURVE PARAMETERS ARE NOT INDEPENDENT!

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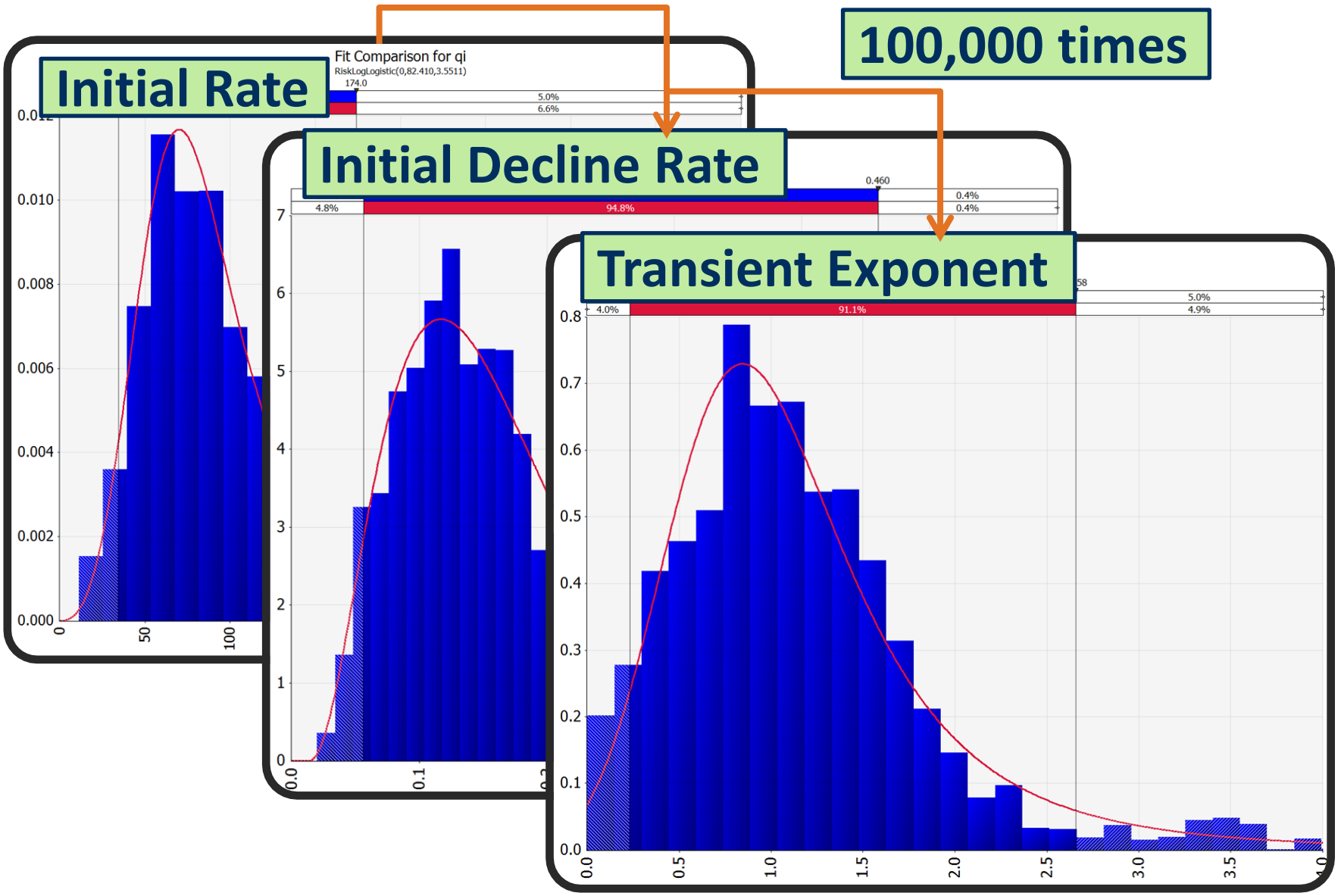
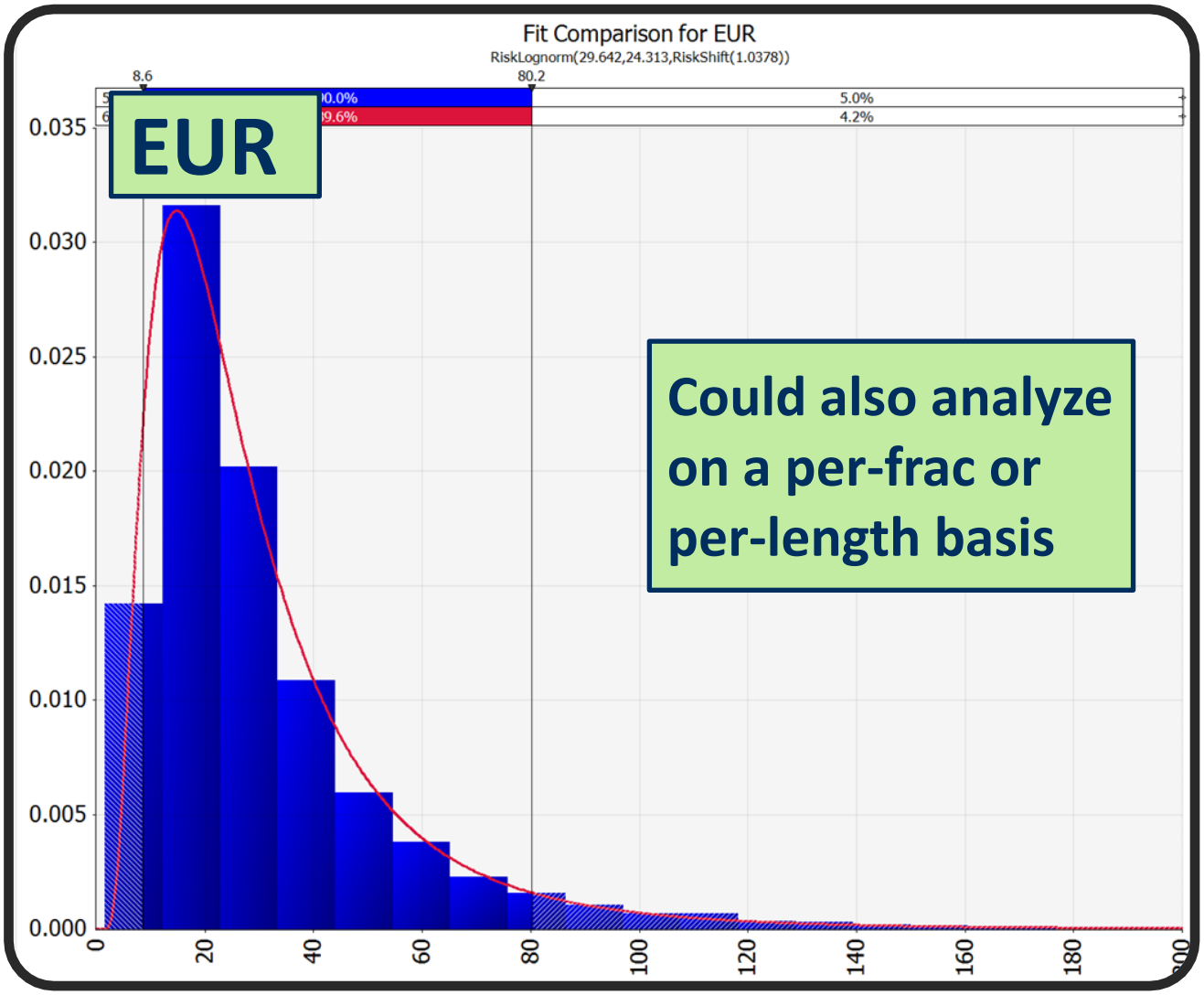
It is nearly always incorrect to move a type curve up or down proportionally to IP – the EUR to IP relationship is nonlinear

Spearman's Correlation Coefficients					
	qi	Di	bt	q1 (adj)	t1
qi	1				
Di	**0.57**	1			
bt	0.11	0.27	1		
q1 (adj)	0.23	-0.09	-0.06	1	
t1	0.15	-0.06	0.03	0.20	1

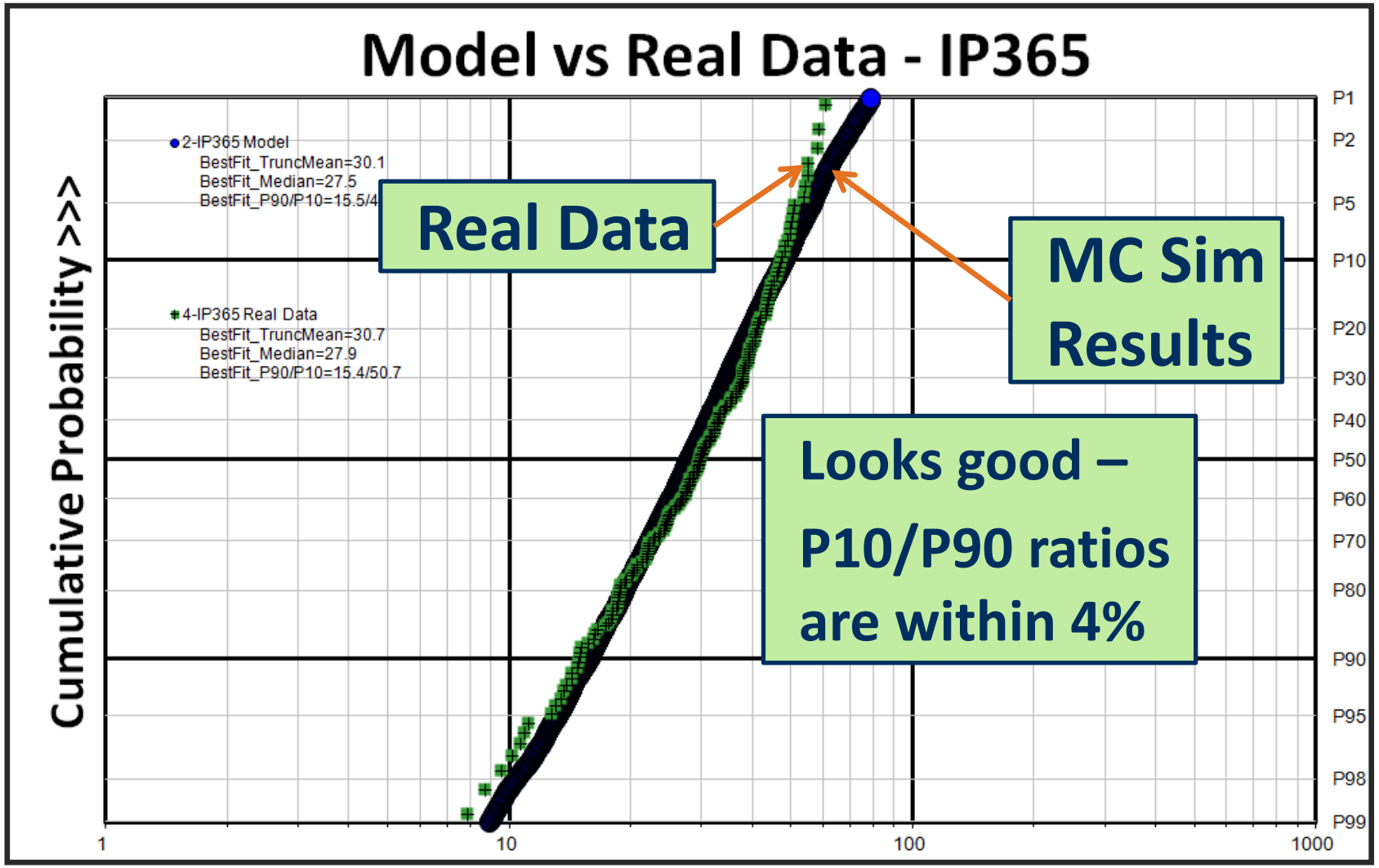
SAMPLING WITH DEPENDENCE - KERROBERT VIKING



SAMPLING WITH DEPENDENCE - KERROBERT VIKING



CONFIRMING PRODUCTION FORECAST RESULTS



CALCULATING REVENUES WITH STOCHASTIC PRICE FORECASTING

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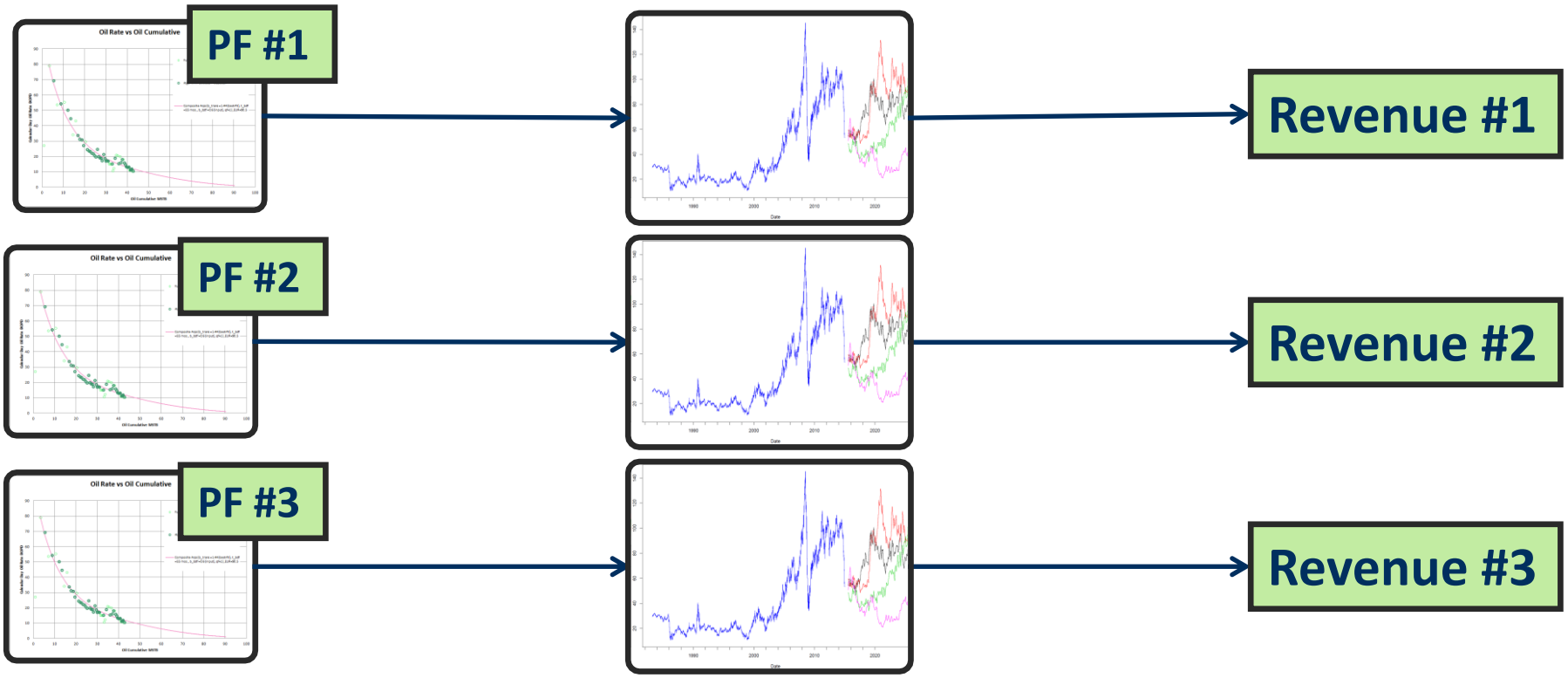
Each of the 100k production forecast realizations is paired with a unique stochastic price forecast realization



STOCHASTIC PRICE FORECASTING: THE ORNSTEIN-UHLENBECK PROCESS

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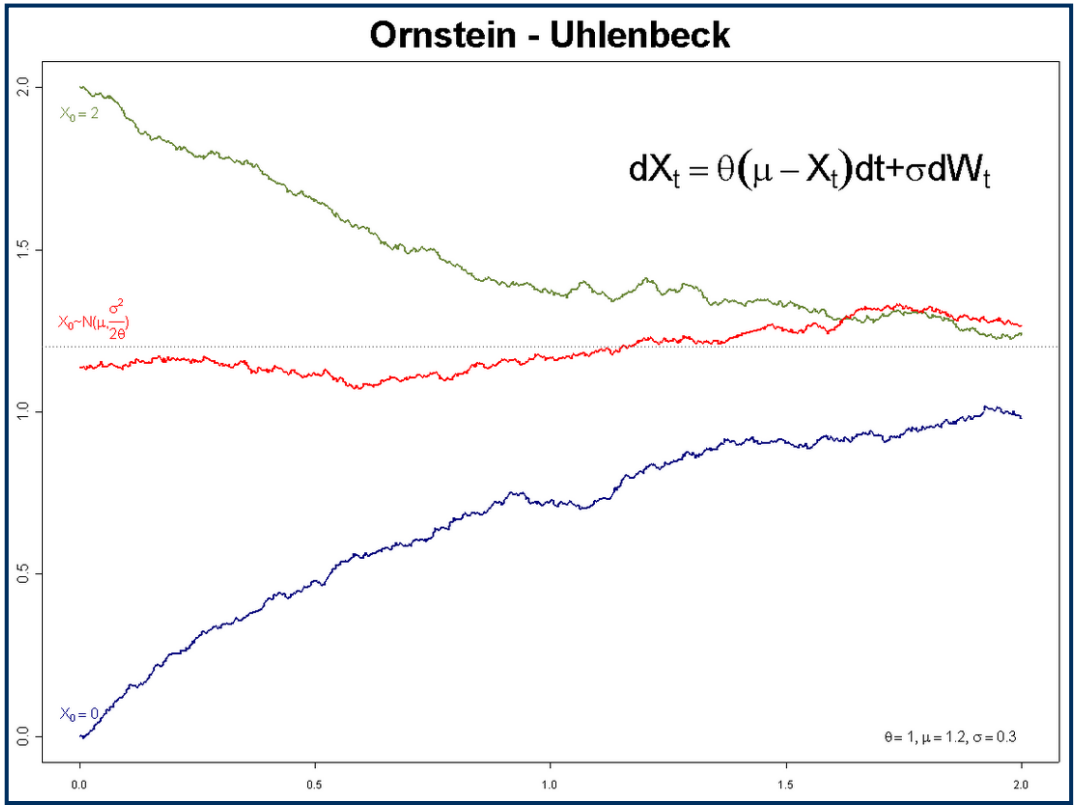
A modified random walk with a mean reversion tendency

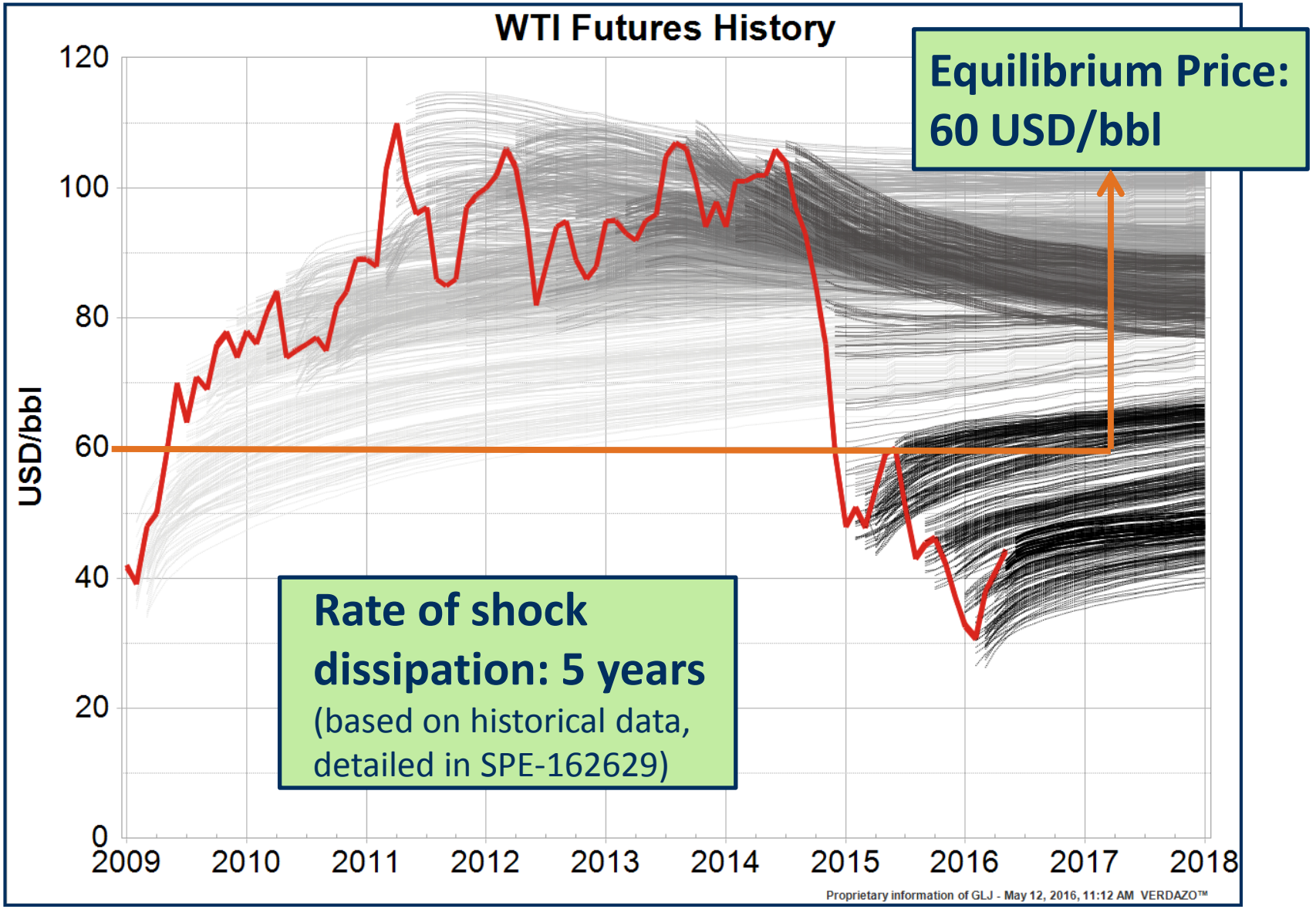
Has four parameters:

- Xo: initial price
- μ: equilibrium price
- σ: volatility
- θ: rate of shock dissipation

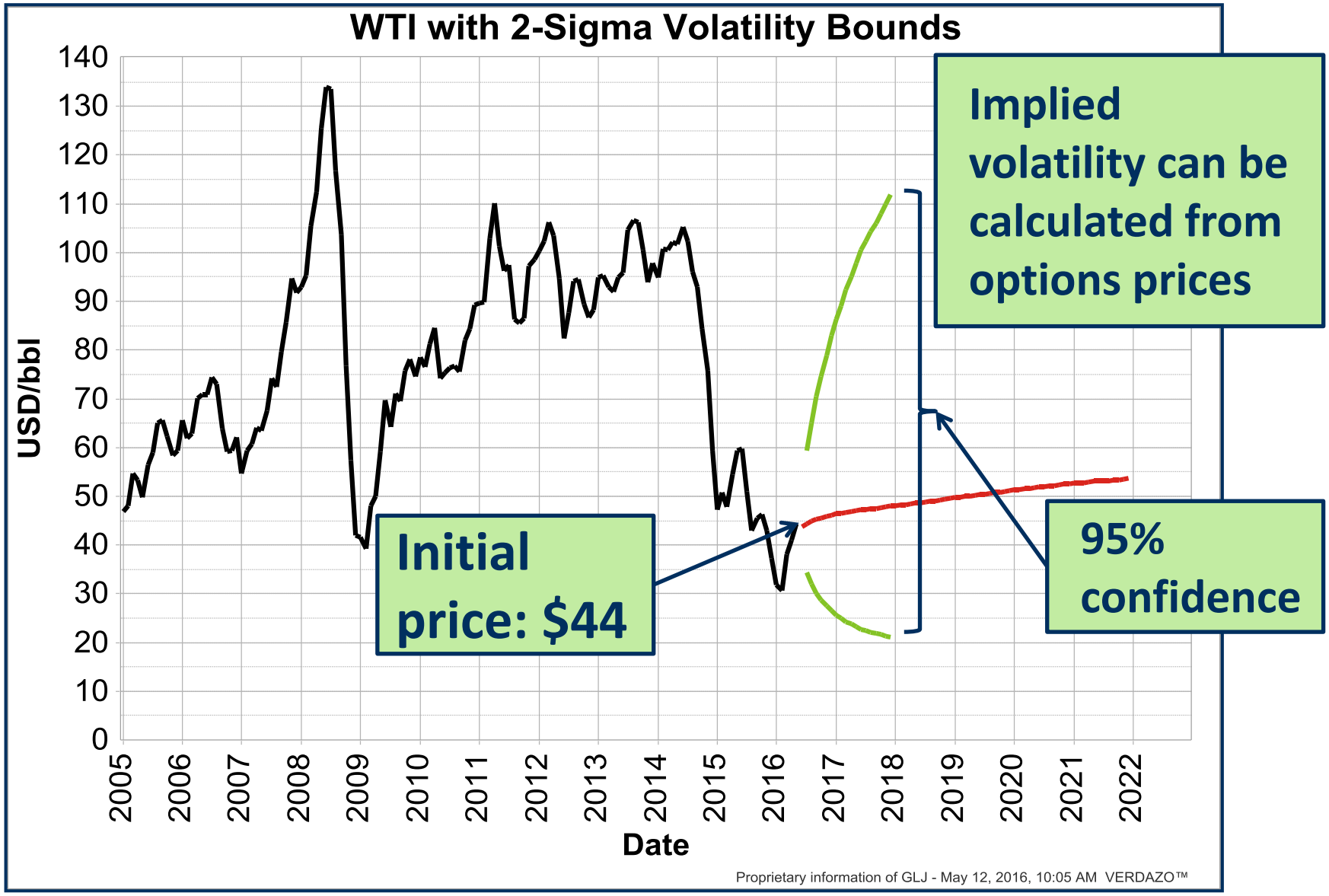


Source: Wikipedia

CHOOSING SUITABLE O-U PARAMETERS



WTI EXPECTED TO BE BETWEEN $21/BBL AND $112/BBL THROUGH 2017



HENRY HUB EXPECTED TO BE BETWEEN $1.55/MMBTU AND $6.00/MMBTU THROUGH 2017

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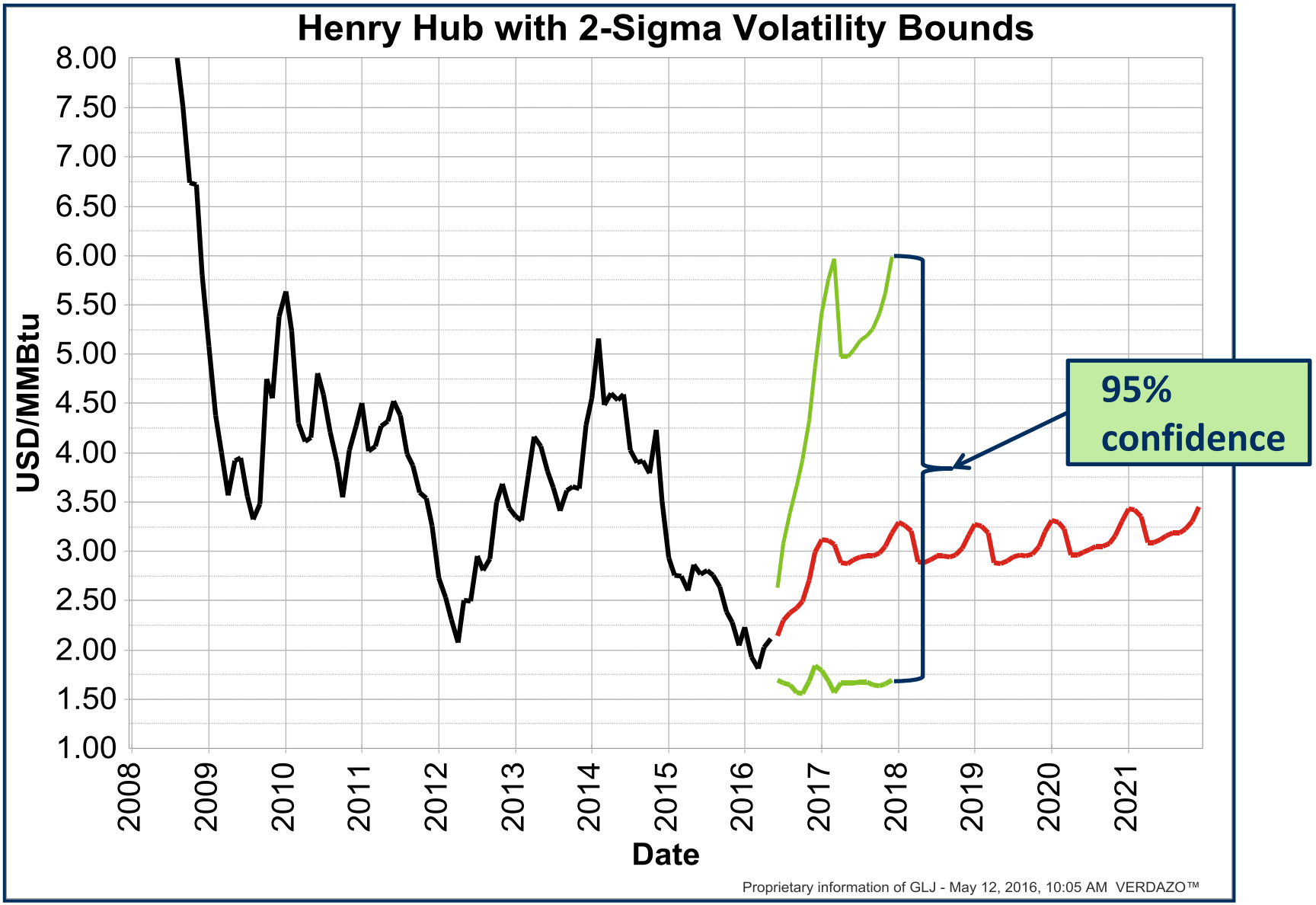
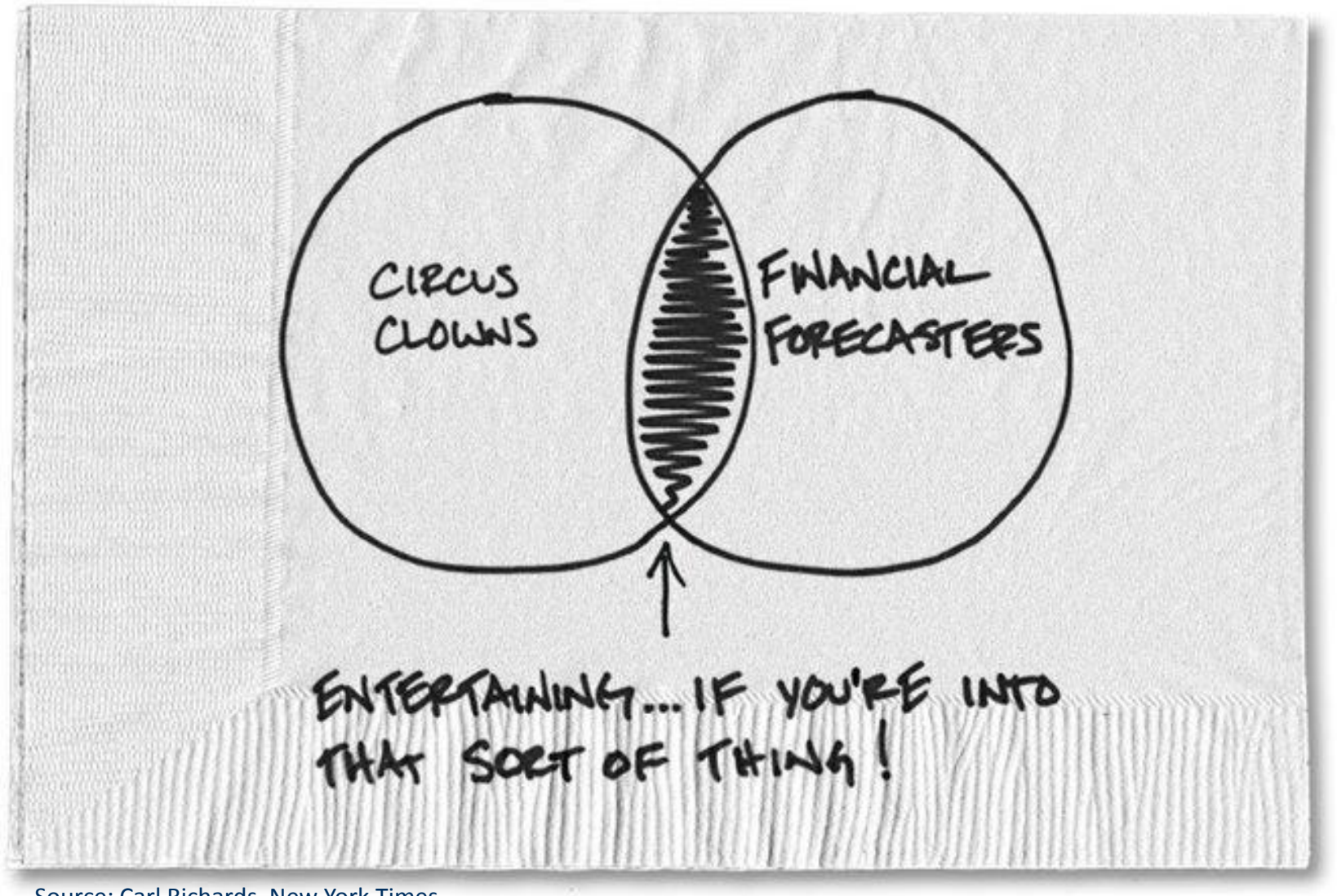
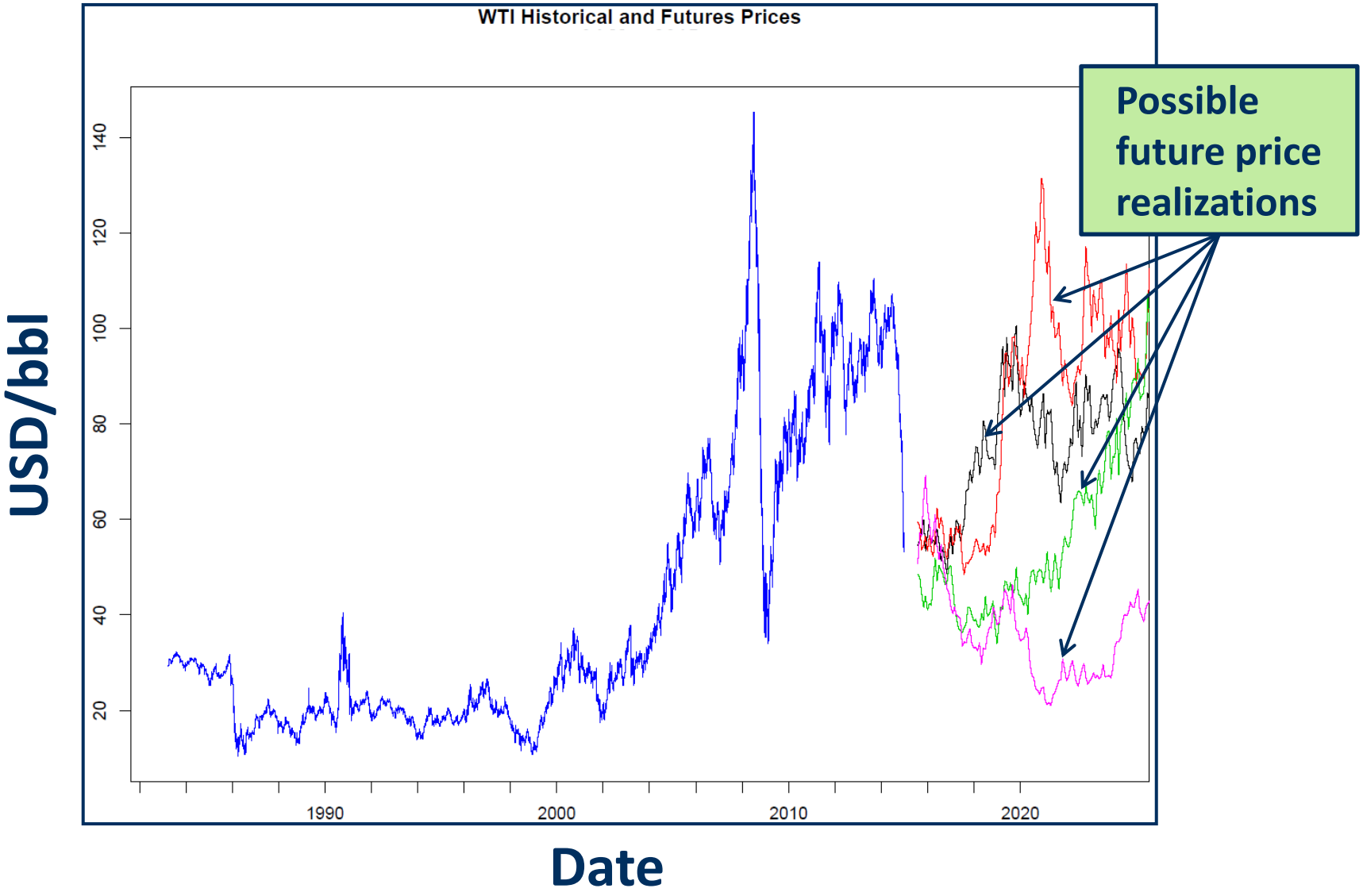


UNCERTAINTY = REALITY

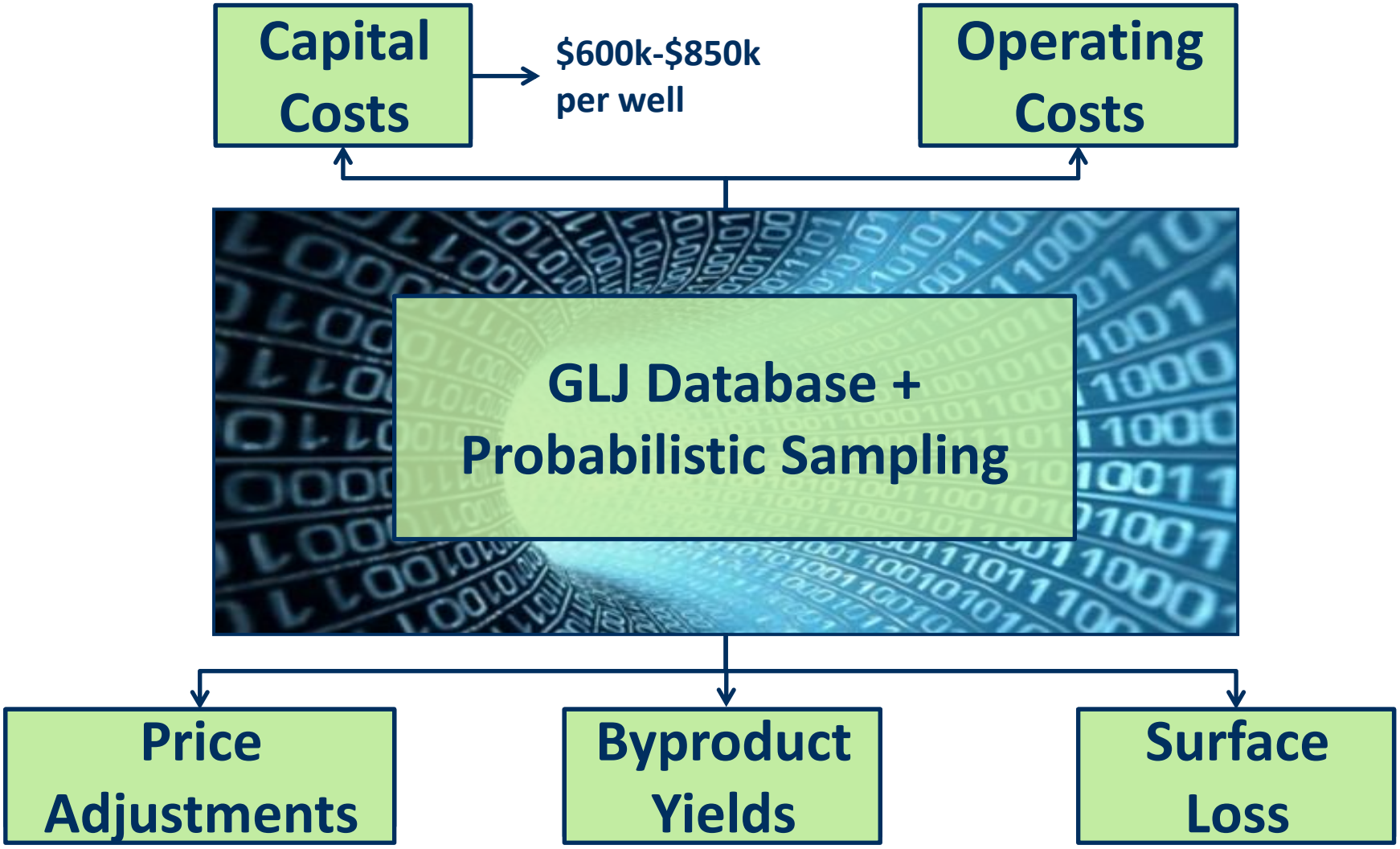


Source: Carl Richards, New York Times

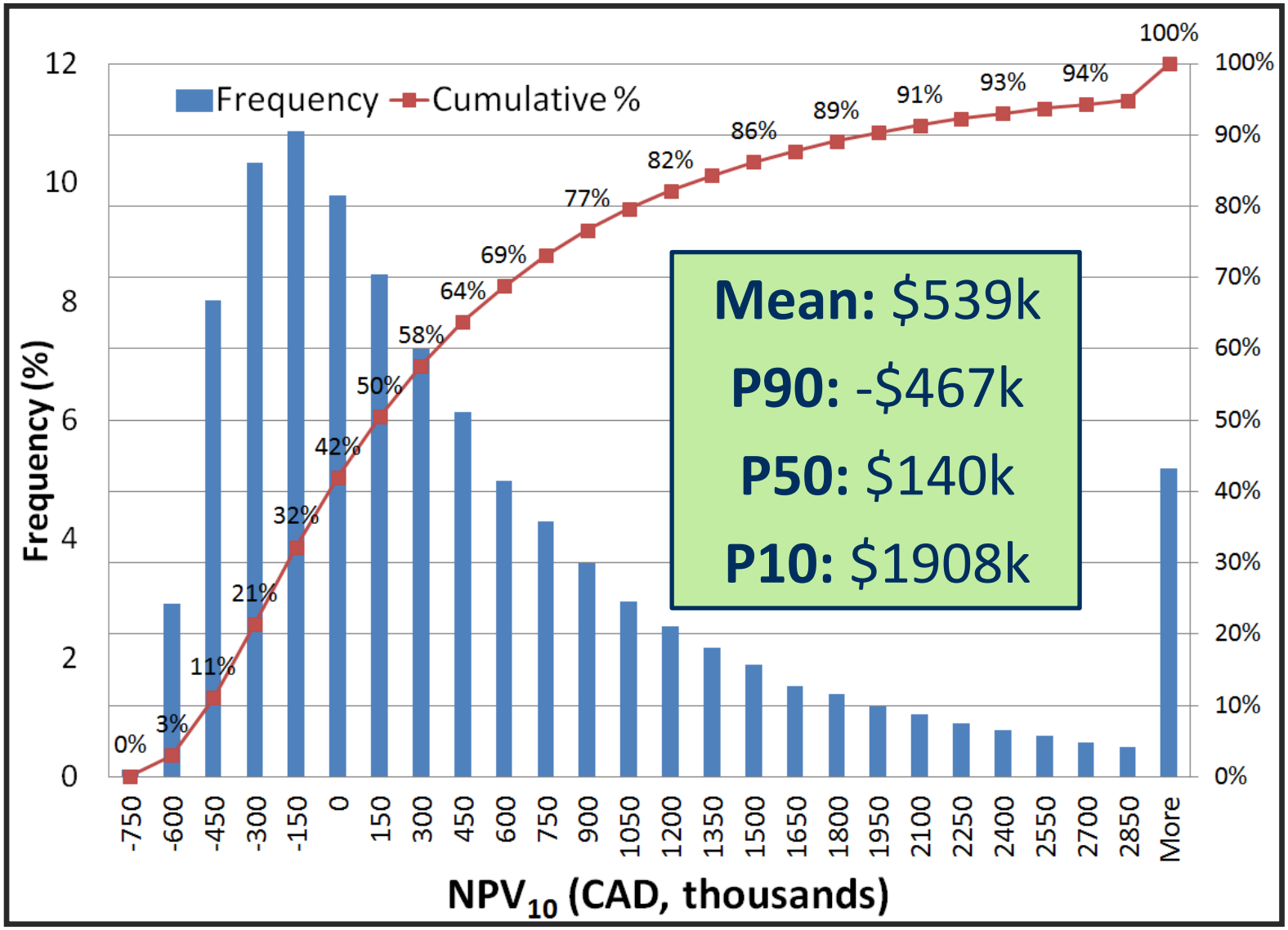
POSSIBLE FUTURE WTI PRICE REALIZATIONS



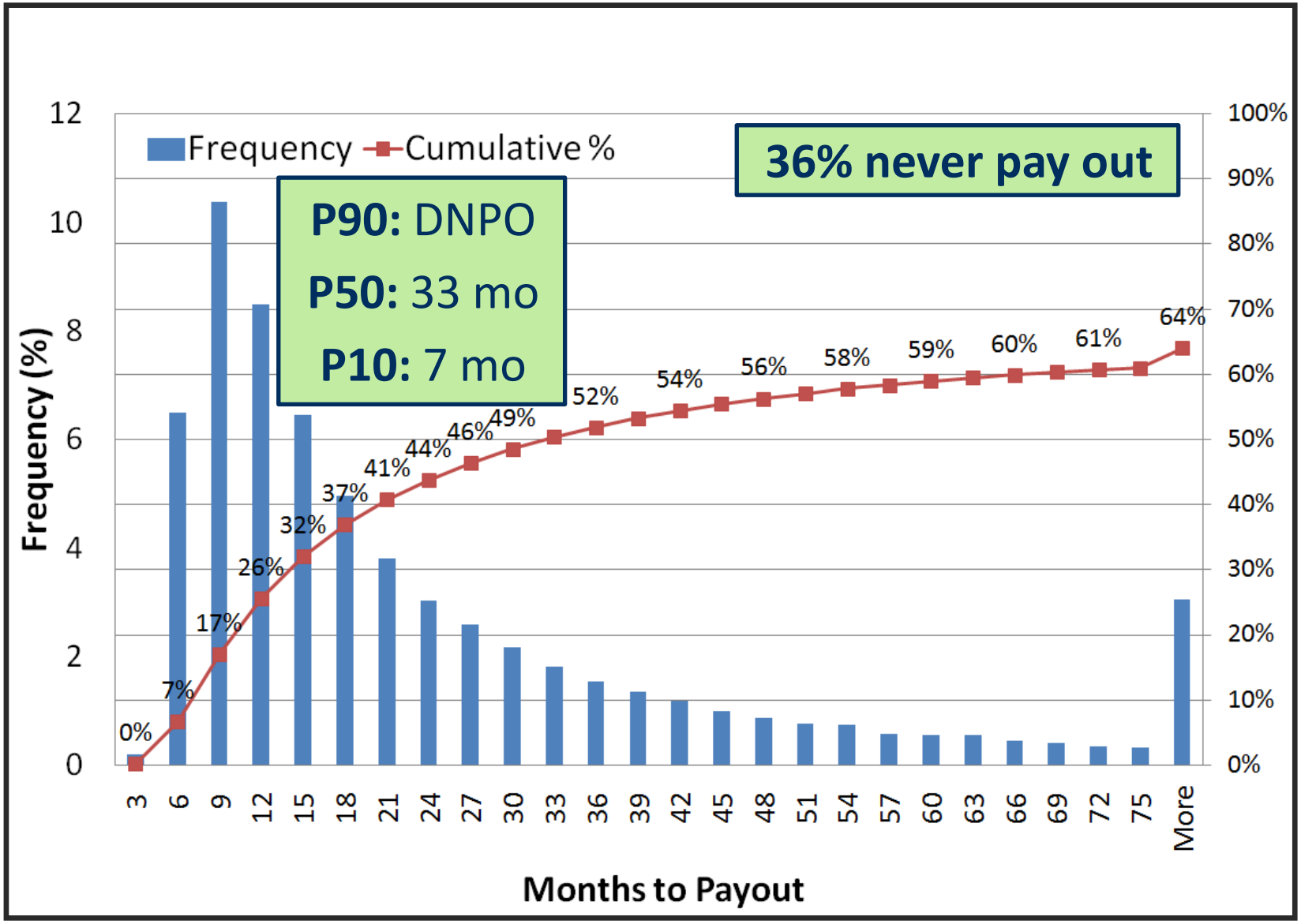
GENERATING FINAL CASH FLOWS



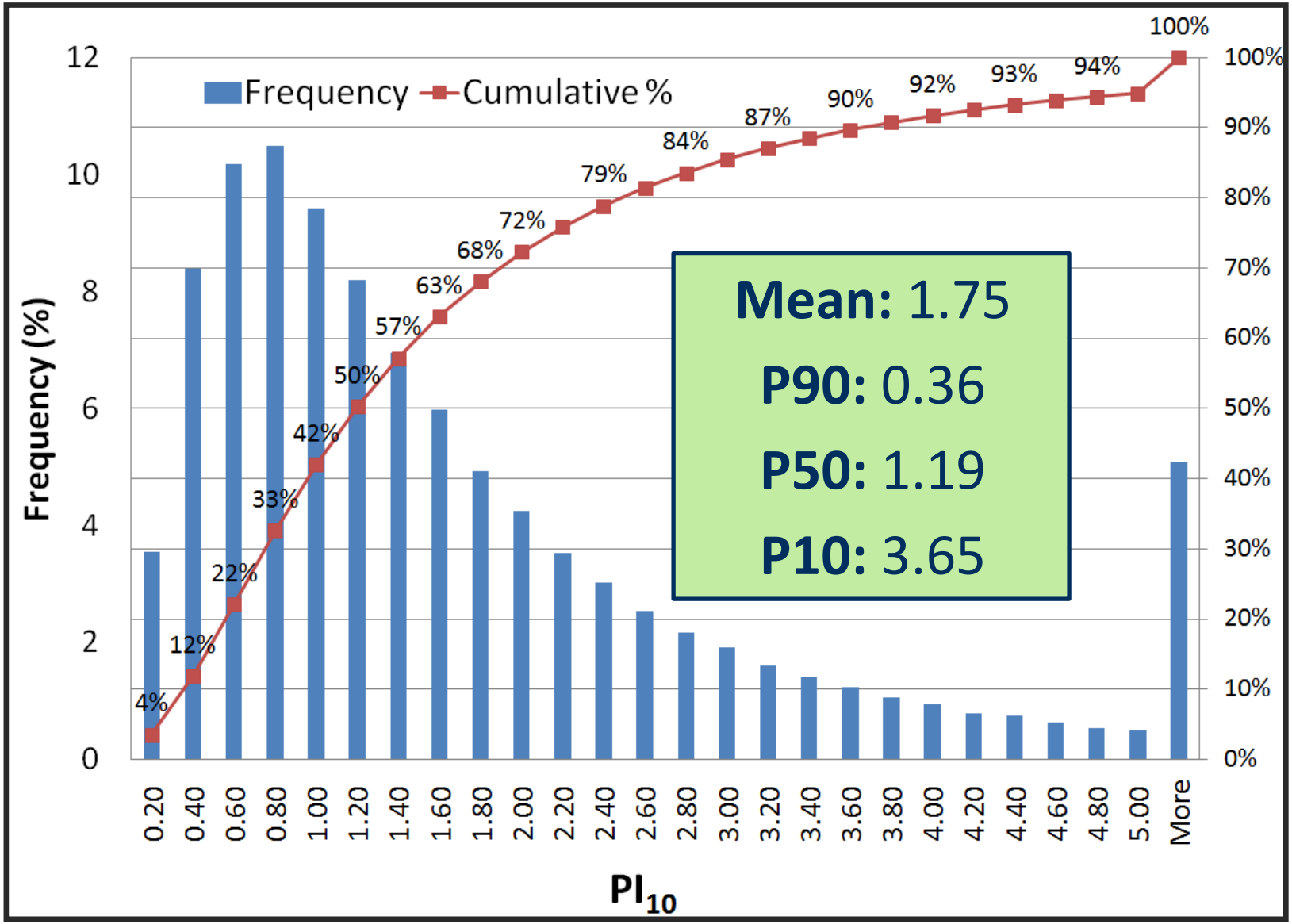
SINGLE WELL NET PRESENT VALUE, 10% DISCOUNTING



SINGLE WELL TIME TO PAYOUT



SINGLE WELL PROFITABILITY INDEX, 10% DISCOUNTING



EXPECTATIONS TIGHTEN WITH MORE WELLS

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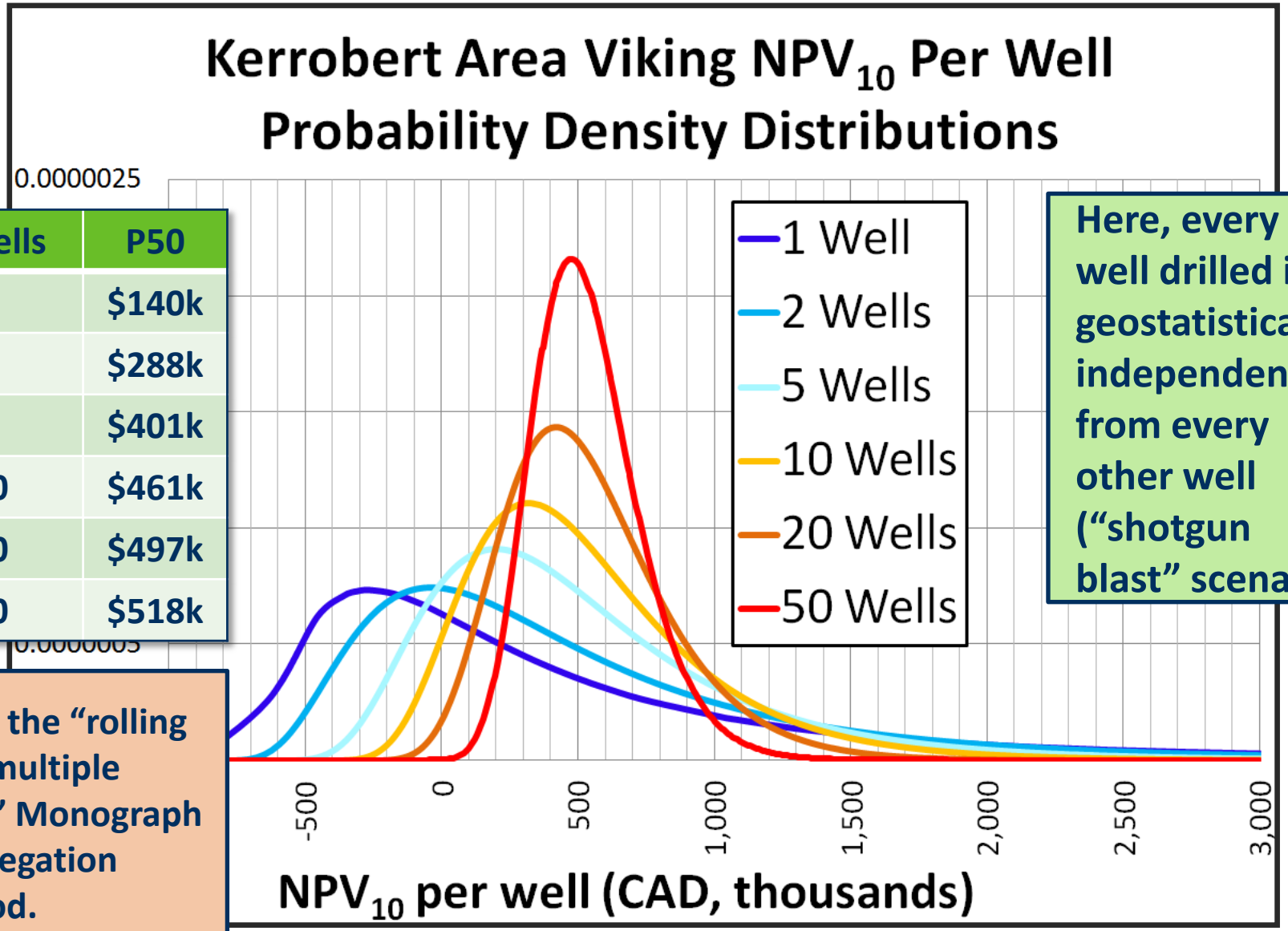

# Wells	P50
1	$140k
2	$288k
5	$401k
10	$461k
20	$497k
50	$518k

Here, every well drilled is geostatistically independent from every other well ("shotgun blast" scenario)

This is the "rolling a die multiple times" Monograph 3 aggregation method.

WHAT IF SEVERAL WELLS ARE DRILLED IN ONE PARTICULAR AREA?

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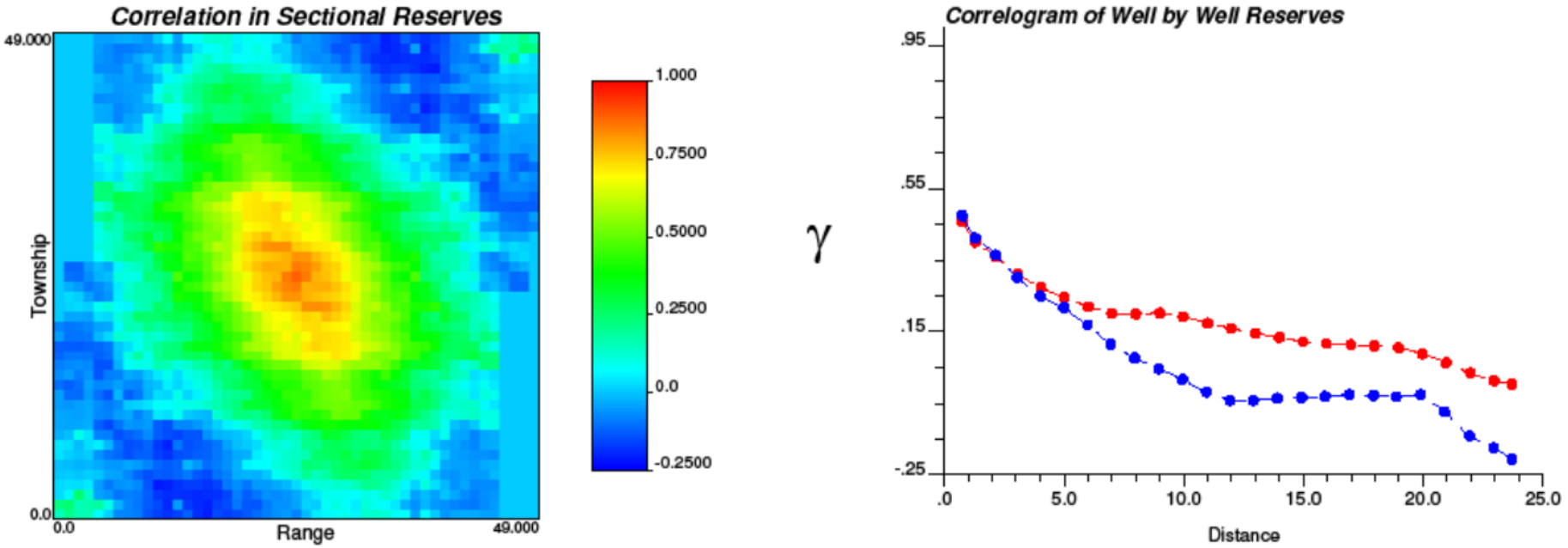
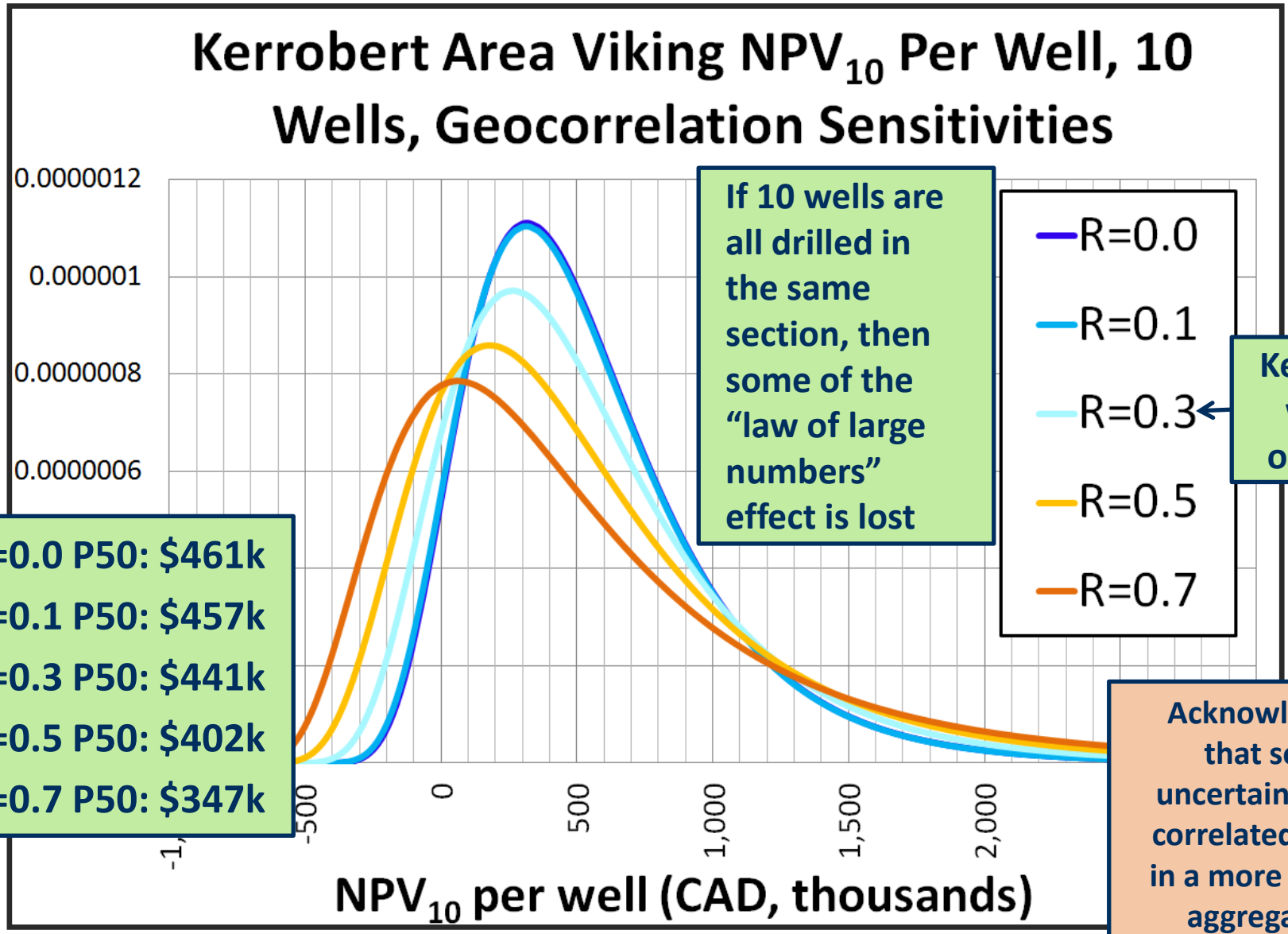
Medicine Hat/Milk River Shallow Gas Example



Wells drilled near each other are likely to perform more similarly than wells drilled farther apart from each other

EXPECTATIONS DON'T TIGHTEN AS MUCH IF AREA OF DEVELOPMENT IS CONCENTRATED

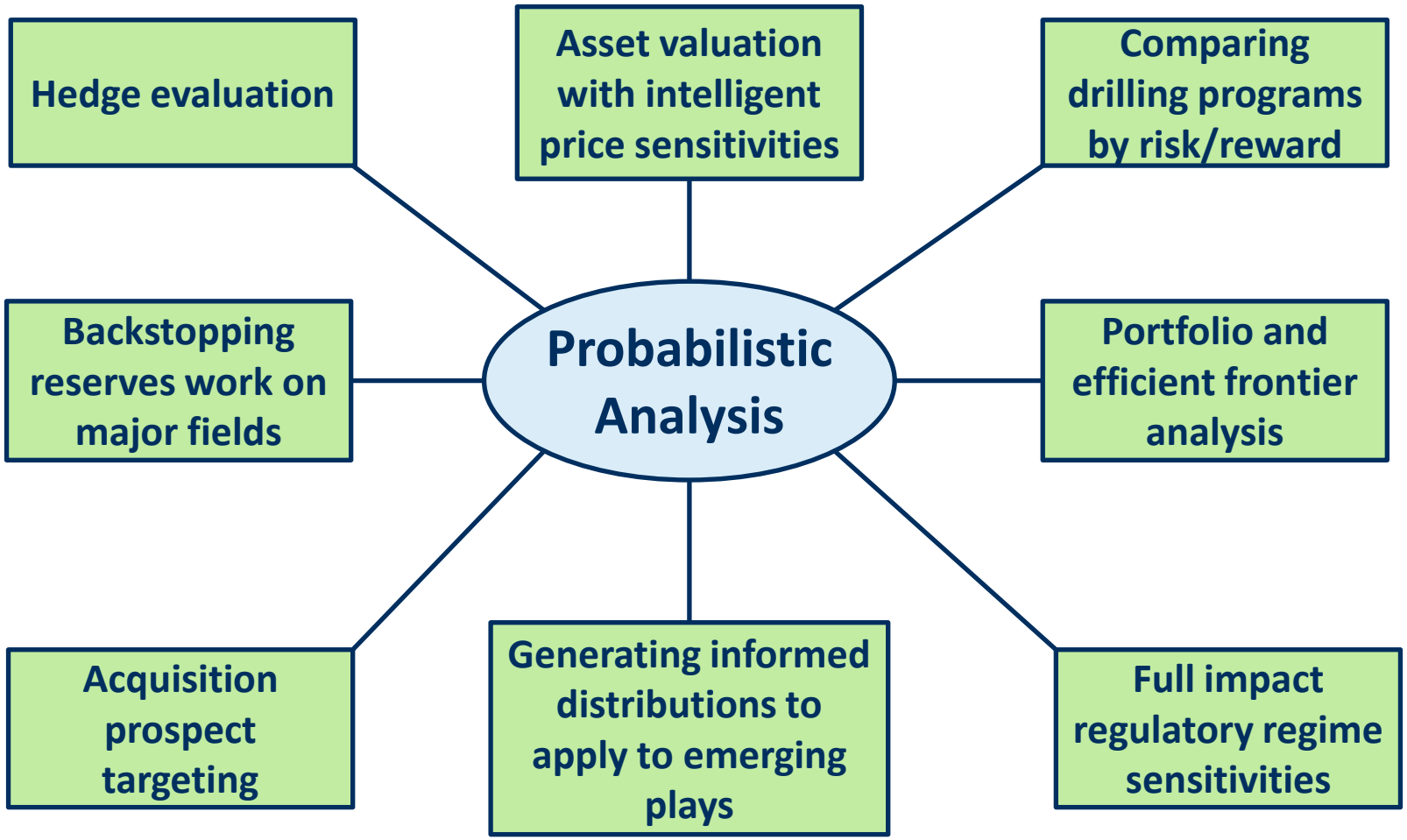


ANSWERS

1. **What is the chance that WTI will average at least 60 USD/bbl in 2017? 27%**
2. **What average 2017 WTI price are we 90% confident will be exceeded? 29 USD/bbl**
3. **How likely is it that a single horizontal Kerrobert Viking well will pay out? 64%**
4. **What is the chance of realizing a NPV_{10} greater than zero for a 10-well drilling program spread across the Kerrobert field? 94%**
   - What if all 10 wells are drilled in the same section? **89%**
5. **How many wells would need to be drilled to be 90% confident of a PI_{10} greater than 1.2? 15**
   - What if all wells are drilled within two miles of each other? **17**

Based on May 3, 2016 market data

APPLICATIONS



THANK YOU

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