Ryder Scott Company
Introduction to
Incorporating Uncertainty in Resource Estimates

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Uncertainties in the Oil and Gas Industry

Geology & Engineering
- Volumes in Place
- Recovery of in Place Volumes
- Production Rate/Volume forecasts
- Cashflow Projections

Product Market
- Volatility in oil and gas prices
  - Lower project revenue
  - Longer development period
  - Higher economic limits and lower reserve volumes
  - Lower shareholder value and return on investment

Operations
- Blowout, casing or tubing collapse, loss of wellbore
- Equipment breakdown, availability
- Weather delays

Monetary Risk
- Inflation / Foreign currency exchange rates
- Capex
- Opex
- Creditors
Uncertainties in the Oil and Gas Industry

• With lower oil prices it is critical to incorporate the uncertainties into business decisions

• Of all decisions that executives make, choosing between optional investment opportunities is often the most difficult

• Important to use consistent evaluation techniques that provide a better understanding of potential outcomes of investment decisions
  • Which one provides the greatest return for the amount of risk?
  • How do you determine how much risk is in an opportunity?
  • How can you determine the most critical elements?

• **Deterministic** or **Probabilistic** method
**Deterministic**
Most common method used in the industry
- Evaluate petrophysical attributes (porosity, thickness, saturations, permeability, skin, etc.)
  - Logs, core
  - Pressure transient analysis
  - Flow tests
- Evaluate geophysical data (reservoir size and limits)
  - 2D, 3D seismic
  - Other prospecting data
- Construct structure and isopach/isochore maps
- Planimeter volumes
- Assign Recovery Factor

Easily understood and widely accepted.

Does not incorporate uncertainty, only presents a single potential outcome based on fixed input variables.
Evaluation Methodologies under SPE-PRMS
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Advantages of Deterministic Methodology
- Well known methodology
- Widely accepted
- Easy to apply and understand

Disadvantages
- Does not fully or correctly incorporate uncertainty
  - Could create high case and low case using different input parameters
    - too optimistic on high case
    - Too pessimistic on low case
    - Just not correct
Probabilistic
Used in the industry but not as common in conventional, very popular in unconventional

- Evaluate petrophysical attributes (porosity, thickness, saturations, permeability, skin, etc.)
  - Logs, core
  - Pressure transient analysis
  - Flow tests
- Evaluate geophysical data (structure size)
  - 2D, 3D seismic
  - Other prospecting data
- Construct distributions for each variable
  - More common: triangular, normal, lognormal
Probabilistic

- Calculate volumes using stochastic volumetric model
- Assign distribution to Recovery Factor
- Calculate the Geologic Chance of Success

Presents a range of expected outcome
Incorporates uncertainty
Evaluation Methodologies under SPE-PRMS

Probabilistic

• Estimate the Geologic Chance of Success
  • Conventional reservoirs
    • Source Rock = .85
    • Timing and Migration = .8
    • Trap = .7
    • Reservoir = .62
    • Total COS = 30%
  • Unconventional reservoirs
    • Presence of shale = 1.0
    • Organics – proper Total Organic Content = 1.0
    • Thermal Maturity – vitrinite reflectance = .7
    • Brittle Lithology – low clay content – high silica = .8
    • Continuity of oil shale = .8
    • Total COS = 45%
Evaluation Methodologies under SPE-PRMS

Probabilistic – incorporating the Chance of Success

Risk Analysis of Exploration Prospects
Probabilistic – incorporating the Chance of Success
Probabilistic

- Calculate volumes using stochastic volumetric model
  - Distributions assigned for input parameters:
    - Area
    - Gross Thickness
    - Net to Gross Ratio
    - Porosity
    - Fluid Saturation
    - Formation Volume Factor
    - Recovery factor

- Covariance between variables
  - Porosity ~ Water saturation
  - Area ~ Net thickness
  - Recovery Factor ~ Net to Gross thickness
Evaluation Methodologies under SPE-PRMS

Probabilistic

- Project Recoverable Volumes using Arps decline equations
  - Distributions assigned for input parameters:
    - Initial rate
    - Decline rate
    - Hyperbolic b factor
    - Minimum decline rate
    - Secondary product yields (Gas – Oil ratio) or (condensate – gas ratio)
  - Covariance between variables
    - Initial Rate ~ Decline Rate
    - Initial Rate ~ Net Thickness
    - Initial Rate ~ Pressure
Evaluation Methodologies under SPE-PRMS

Probabilistic

- Calculate economic value using stochastic model
  - Distributions assigned for input parameters:
    - Product prices
    - opex
    - capex
  - Covariance between variables
    - Product prices ~ opex
    - Product prices ~ capex
    - Capex ~ Initial Rate
Evaluation Methodologies under SPE-PRMS

Probabilistic

• Results in a range of outcomes
  • Original Volumes in Place
  • Recoverable Volumes
  • Economic Value – Net Present Value
    • Opex
    • Capex

• Allows Managers to understand and incorporate uncertainties
  • Better decisions
  • Positions company for better profitability
Evaluation Methodologies under SPE-PRMS

Probabilistic

- Where can you use it?
  - Determine most likely outcome of a workover campaign
    - Which is the most cost efficient workover
  - Shale Prospect Analysis
  - Undiscovered Conventional Reservoir Prospect Analysis
  - Exploration of Undrilled Acreage
  - Infill drilling
Evaluation Methodologies under SPE-PRMS