Analytics in Unconventional Plays

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Ryder Scott Company
What You Are Thinking

Well spacing is the real key, that is why my company is developing all wells at 625' spacing to maximize value.

Our company knows the real way to increase NPV is longer laterals and more stages.

We just increased first year production by 15,000 barrels by increasing our proppant and fluid volume!
You should use an analytic multivariate approach to maximize value!
The Challenge

- Completion designs are changing rapidly

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology</td>
<td>Best</td>
<td>Good</td>
<td>OK</td>
</tr>
<tr>
<td>Lateral Length</td>
<td>5,000</td>
<td>7,500</td>
<td>9,500</td>
</tr>
<tr>
<td>Proppant LBS/FT</td>
<td>2,000</td>
<td>1,500</td>
<td>2,500</td>
</tr>
<tr>
<td>Stage Length</td>
<td>300</td>
<td>280</td>
<td>200</td>
</tr>
<tr>
<td>Well Spacing</td>
<td>262</td>
<td>625</td>
<td>525</td>
</tr>
<tr>
<td>Reserves BBL/LatFT</td>
<td>61</td>
<td>72</td>
<td>60</td>
</tr>
</tbody>
</table>

- Considering all factors, can an operator create a better development plan to maximize value of future wells?
Methodologies

- Neural Networks
- Random Forests
- Decision Trees
- Regression

Linear Regression:
- Meaningful insights
- Easy to interpret
- Very accessible

Interpretability

Learning Capacity
What is Multivariate Regression Analysis

Single Variable Relationships
- Lateral Length
- LBS/FT
- Spacing
- Stage Length
- STOOIP

Combined Multivariate Relationship

Statistical Analysis Aids Understanding:
- Significance of geologic variables
- Impacts of individual variables
- Impacts of ever changing completion designs
- Value improvement insights
What is Multivariate Regression Analysis

R² is the amount of variation in the dependent variable explained by the independent variables.

Multivariate Regression Analysis generates an equation:

- **Variable List**
  - Intercept
  - Lateral Length
  - Proppant LBS/FT
  - Well Spacing
  - Stage Length
  - STOIP (MMBLS)

- **MRA Weights**
  - Intercept: 200,000
  - Lateral Length: 56
  - Proppant LBS/FT: 120
  - Well Spacing: 300
  - Stage Length: -400
  - STOIP (MMBLS): 8,000

- **Well Values**
  - Intercept: 7,000
  - Lateral Length: 1,200
  - Proppant LBS/FT: 500
  - Well Spacing: 350
  - Stage Length: 19
  - STOIP (MMBLS): 0

- **MRA Equation**
  \[ \text{MRA Equation} = \text{Well Values} \times \text{MRA Weights} \]

- **R²**
  \[ r^2 = 0.810 \]
• Each continuous variable is described by a line or curve

• A linear relationships implies that each incremental lateral foot will bring about an equal change in reserves or production

• Other relationships, such as a logarithmic fit, imply a diminishing return in reserves or production for each addition foot drilled

Engineers and Geologists need to work with the statistician

– Engineering and geology principles are applied and need to be continuously considered
Variable Importance and Time

- Variable importance changes depending on the period of time or area under study
- Early time: Completion variables are more impactful
- EUR: Geologic/spacing variables are more impactful

**EUR Variable List**
- Effective Lateral Length
- Proppant LBS/FT
- Proppant Concentration
- Stage Length
- STOOIP
- Well Spacing
Key Variable Impact

- With completion designs changing, how should reserves volumes be estimated?
- Are these variables actually causing a change in reserves?
- Are there additional variables that should be considered?

![Graph showing correlation between MRA Predicted Oil EUR and Engineer Oil EUR](image)

![Bar charts comparing Stage Length, Fluid, and Proppant across generations](image)

![Bar charts comparing Initial Production Rates across different time points for each generation](image)
Key Variable Impact

- With completion designs changing, how should reserves volumes be estimated?
- Are these variables actually causing a change in reserves?
- Are there additional variables that should be considered?

R² increases from 0.32 to 0.65
Determination of Categorical Differences

- Is there a difference in completion type performance?
  Completion Type 2 wells produce 35,000 additional bbls in the first two years of production

Variable List
- Effective Lateral Length
- Proppant LBS/FT
- Stage Length
- Well Spacing
- Fluid Properties
- Completion Type
- Geology
Determination of Categorical Differences

- Is there a difference in completion type performance?
  Completion Type 2 wells produce 35,000 additional bbls in the first two years of production

- What other categorical differences could be tested?
  - Reservoirs
    Do they act similarly to completions when limited geology is available?
  - Operators
    Do they achieve similar results?

Actual 24Mo Prod

Completion Type 1
Completion Type 2

MRA Predicted 24Mo Prod

r² = 0.528
Determine if an operator with overlapping acreage is performing better or worse than other operators when taking into account relevant differences.

**Variable List**
- Intercept
- Lateral Length
- Proppant LBS/FT
- Well Spacing
- Infill Drilling Factor
- STOOP
- Operator A/B

**MRA Weights**
- Intercept: -200,000
- Lateral Length: 56
- Proppant LBS/FT: 120
- Well Spacing: 300
- Infill Drilling Factor: -400
- STOOP: 8,000
- Operator A/B: 50,000

**Well Values**
- Intercept: 7,000
- Lateral Length: 1,200
- Proppant LBS/FT: 500
- Well Spacing: 350
- Infill Drilling Factor: 19
- STOOP: 0
- Operator A/B: 0

**MRA Equation**

\[-200,000\times7,000 + 56\times1,200 + 120\times500 - 400\times350 + 8,000\times19 + 50,000\times0\]

\[-140,000\text{ (intercept)} + 152,000\text{ (STOOP)} + 0\text{ (Operator A/B)}\]

\[\sum 498,000\]
Benchmarking

Determine if an operator with overlapping acreage is performing better or worse than other operators when taking into account relevant differences.

Variable List

- Intercept
- Lateral Length
- Proppant LBS/FT
- Well Spacing
- Infill Drilling Factor
- STOOIP
- Operator A/B

MRA Weights

- 200,000
- 56
- 120
- 300
- - 400
- 8,000
- 50,000

Well Values

- 7,000
- 1,200
- 500
- 350
- 19
- 1

MRA Equation

\[-200,000 + 392,000 + 144,000 - 140,000 + 150,000 - 152,000 + 50,000 = 548,000\]

What is different between the operators?
Estimating Variable Impact

<table>
<thead>
<tr>
<th>Variable List</th>
<th>MRA Weights</th>
<th>Well Values</th>
<th>MRA Equation</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-200,000</td>
<td></td>
<td>= -200,000</td>
<td>7.9%</td>
</tr>
<tr>
<td>Lateral Length</td>
<td>56 x</td>
<td>7,000</td>
<td>= 392,000</td>
<td>7.9%</td>
</tr>
<tr>
<td>Proppant LBS/FT</td>
<td>120 x</td>
<td>1,200</td>
<td>= 144,000</td>
<td>2.9%</td>
</tr>
<tr>
<td>Well Spacing</td>
<td>300 x</td>
<td>500</td>
<td>= 150,000</td>
<td>3.0%</td>
</tr>
<tr>
<td>Stage Length</td>
<td>-400 x</td>
<td>350</td>
<td>= -140,000</td>
<td>-2.8%</td>
</tr>
<tr>
<td>STOOIP (MMBLS)</td>
<td>8,000 x</td>
<td>19</td>
<td>= 152,000</td>
<td></td>
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<td><strong>Σ</strong></td>
<td><strong>498,000</strong></td>
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Lateral Length: 56 x 700 = 39,200 7.9%

Examine how a 10% change in the Well Value affects the equation results.

Sensitivity testing the equation evaluates the impact of each individual variable.
### Estimating Variable Impact

**Passing Results**

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<tr>
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<tr>
<td>Lateral Length</td>
<td>19.4 %</td>
</tr>
<tr>
<td>Proppant LBS/FT</td>
<td>6.5 %</td>
</tr>
<tr>
<td>Well Spacing</td>
<td>1.4 %</td>
</tr>
<tr>
<td>Stage Length</td>
<td>-2.2 %</td>
</tr>
<tr>
<td>Fluid BBL/FT</td>
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Screen for outsized individual variable impacts

Sensitivity testing the equation evaluates the impact of each individual variable
Estimating Variable Impact

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Screen for outsized individual variable impacts

Gain insights into trends of impact variables

Ryder Scott has seen general trends for specific parameters during sensitivity testing
Is This Reliable Technology?

(2008) (25) **Reliable technology.** Reliable technology is a grouping of one or more technologies (including computational methods) that has been field tested and has been demonstrated to provide reasonably certain results with **consistency** and **repeatability** in the formation being evaluated or in an analogous formation.

- Multivariate regression analysis can be considered reliable technology
- Reliability should be demonstrated on a case by case basis
- Sufficient evidence as to what constitutes reliable technology should also be determined on a case by case basis
• Engineering and geology concepts still apply

• Multivariate analysis aids understanding:
  – Significance of geologic variables
    • To what degree does the well’s location impact performance?
  – Impacts of individual variables
    • How much will reserves increase if the average lateral length increases?
    • Will additional completions intensity increase production enough to offset costs?
  – Impacts of ever changing completion design
    • With many design elements changing, what is causing the observed change in performance?
  – Value improvement insights
    • Optimization of completions designs and field development plans

Conclusion