EXPLORATION AND PRODUCTION (E&P)

How to Choose and Manage Exploration and Production Projects

Term Project

May 9, 2001

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DEFINITION

What is E&P

E&P is the business of finding Petroleum or Gas and getting out of the ground

Why choose E&P

Because it is a risky business and most E&P projects fail while a few are successful
THE UNCERTAINTIES OF E&P PROJECTS ARE DIVIDED INTO 2 CATEGORIES

**Local uncertainties**
- Involve the discovery and production of oil & gas at the site such as
  - Place

**Global uncertainties**
- Involve outside conditions such as
  - Prices and costs
  - Change and demand or transportation system
  - Change in technology of exploration
  - Change in regulation
OBJECTIVES OF THE PROJECT

1. Understand how to **quantify the risk of the E&P projects and entire portfolio of producing properties**, including diversification effects.

2. Understand how to **manage the risk and find the best diversification strategy** (optimization portfolio).
Obtaining the **NPV and Costs** of total 7 projects A-G

- Each of them have **different physical properties**
## PROPERTIES OF THE EXAMPLE PROJECTS

<table>
<thead>
<tr>
<th>Produced Fluid</th>
<th>Project Location</th>
<th>Scale of example</th>
<th>Area, acres</th>
<th>Thickness, feet</th>
<th>Porosity, %</th>
<th>Initial Hydrocarbon Saturation</th>
<th>Permeability, mD</th>
<th>Depth, feet</th>
<th>Oil Viscosity, cP</th>
<th>Temperature, °F</th>
<th>Initial pressure, psi</th>
<th>Price assumptions ($/unit)</th>
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<td>13</td>
<td></td>
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### MEAN PROPERTIES

- **Location**: MEAN PROPERTIES
- **Produced Fluid**: Initial Hydrocarbon saturation
- **Scale of example**: Well
- **Location**: Gulf Coast, Calif., W. Texas, Alberta, Mid-Cont., Alberta, Gulf Coast
- **Area, acres**: Mean values vary from 160 to 640
- **Thickness, feet**: Mean values vary from 8 to 29.8
- **Porosity, %**: Mean values vary from 13 to 24.3
- **Initial Hydrocarbon saturation**: Mean values vary from 75 to 78
- **Permeability, mD**: Mean values vary from 13 to 258
- **Depth, feet**: Mean values vary from 5500 to 13372
- **Oil Viscosity, cP**: Mean values vary from 10 to n/a
- **Temperature, °F**: Mean values vary from n/a to 287
- **Initial pressure, psi**: Mean values vary from 2382 to 5787
- **Price assumptions ($/unit)**: Mean values vary from 2 to 2
DETAILS OF PROJECT

- Total **140 scenarios of correlated data set have been generated** from the sources we obtained.

- Then, we also using **@risk to generate another 10,000 scenarios**.
FUNDAMENTAL CONCEPTS THAT WE USED FROM THE CLASS

1. **LP Optimization Modeling** - budget & capital allocation problem

2. **Risk and Uncertainties Modeling**

3. **Goal Programming**
APPLIED CONCEPTS THAT WE USED

1. Conventional Approach
2. Markowitz Model
3. Mean Absolute Deviation
Decision rule, those with **highest NPV/I** was selected until the **capital budget** was exhausted

Maximize $\sum P_i X_i$ (Maximize return)
Subject to $\sum C_i X_i \leq B$ (Budget Constraint)

$X_i \leq 1$

$X_i \geq 0$

$P_i = \text{NPV or Return of project } i$

$X_i = \% \text{ funded for project } i \times 100$

$B = \text{Capital Budget}$
CONVENTIONAL APPROACH RESULT (1/2)

$2 Million Budget

% Funded

100%

Project

A B C D E F G

18.24%
## CONVENTIONAL APPROACH RESULT (2/2)

<table>
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<tr>
<th>Project</th>
<th>% Funded (x100%)</th>
<th>Investment x$1000</th>
<th>NPVx$1000</th>
<th>Costs x$1000</th>
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<td>$121.40</td>
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</table>

**Total Investment: $2,000.00**
2. MARKOWITZ MODEL (1/2)

• The model embodies **Harry Markowitz**’s original expression for risk return trade-off

• The risk is measured by the **variance** and using the input of expected return and **full covariance matrix** of assets

• Using the concept of **Efficient Frontier**
  – Each point on the efficient frontier has minimized the risk for that level of expected return
  – The best portfolios are those according to the point on the efficient frontier itself
Minimize $\sigma^2 = XQX^t$ (Min Variance)

S.T. 1) $\Sigma x_i = 1$ (Budget constraint)

2) $\Sigma r_i x_i \geq E$ (Expected return of at least $E$)

3) $x_i \geq 0$

$x_i = \%$ of portfolio in asset $i$ (Weight of asset $i$)

$Q =$ Covariance Matrix

$r_i =$ Expected return of $i$th asset
<table>
<thead>
<tr>
<th>Return</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>W7</th>
<th>Risk(VAR)</th>
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MARKOWITZ MODEL RESULT (2/2)
MAD is an alternative measure of risk that is sometimes advantageous over variance. This model contrasts with the Markowitz in some ways.

- It measures risk in term of mean absolute deviation instead of variance.
The MAD model is **linear** as opposed to non-linear of Markowitz model and that can take the full advantage of large scale **Linear Programming (LP) code**

- It can take scenarios of historical returns or Monte Carlo simulation directly as input instead of using summary statistics.
Minimize MAD = Average( y_j )
S.t.  
1) $\sum x_i = 1$ (Budget constraint)
2) $\sum r_i x_i \geq E$ (Expected return of at least E)
3) $\sum s_{ij} x_i - \sum r_i x_i \leq y_j$ (Upside of absolute value)
4) $\sum r_i x_i - \sum s_{ij} x_i \leq y_j$ (Downside of absolute value)
5) $x_i \geq 0$

$x_i$ = % of portfolio in asset i (Weight of asset i)
$r_i$ = Expected return of i th asset
$s_{ij}$ = Return of asset i under the j th scenario
$y_j$ = Absolute deviation of the return of the j th scenario from the expected return
• Modified MAD model to take into by minimizing only the down-sided risks at a single fixed rate of penalties

• Each unit of the downside deviation from the mean will be penalized linearly with certain fixed cost
MAD WITH MULTIPLE PENALTIES

- In addition to the case of a single fixed cost for downside risk penalty, we then **add an additional high penalties cost** if the downside deviation are higher than acceptable value.

- This model is **minimized only the down-sided risks at a multiple fixed rate of penalties**.
## MAD RESULT (1/2)

<table>
<thead>
<tr>
<th>Return</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
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MAD WITH MULTIPLE PENALTIES RESULT
COMPARISON (BY USING THE SIMULATION DATA)
Using the Markowitz model and MAD model, we can see that both methods have accounted the risk into the model while the Conventional method does not.

MAD and Markowitz model provide us better results than conventional method. By looking at the same amount of return of the portfolio, both MAD and Markowitz model give us less risk than the Conventional technique.
• By comparing the Markowitz model with MAD model, the efficient frontier results from these methods are consistent in terms of the weight among each investment.

• MAD is the best approach for this kind of data set as the input (Different Scenarios) instead of using summary statistics.
The extended objectives and works would be as follow,

- **What should we pay for a new project**, given the projects already in our portfolio?

- How would oil projects, as contrasted from gas projects, affect **the impact of price uncertainty** on my portfolio?
Q & A