Simulation of Crude Oil Exploration & Production

By Aditya Sastry

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Project Overview

The Petroleum Industry

Upstream
The process of **exploring** potential oilfields and **producing** crude oil and natural gas when discovered (E&P)

Midstream
Primarily concerned with connecting the upstream and downstream with transportation and storage as well as some processing

Downstream
Refining the products, marketing, and point of sale operations are the bulk of the downstream sector

Project Goals & Narrative

- A firm is interested in drilling a single onshore well for crude oil in Northern Texas
- Analyze the costs of Exploration in detail
- Forecast the price of crude (WTI-spot)
- Generate production forecasts and costs
- Understand NPV of entire E&P operation
- 5 years to break even

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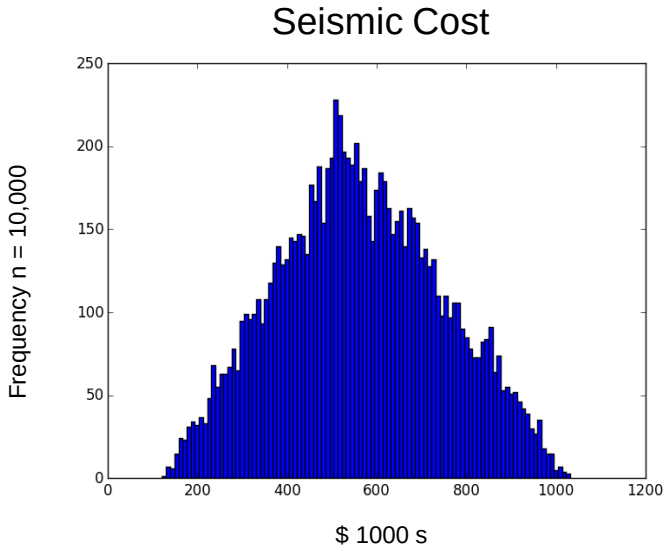
E&P Model


Exploration
Simulation

Pre-Hydrocarbon Discovery

Seismic Methods

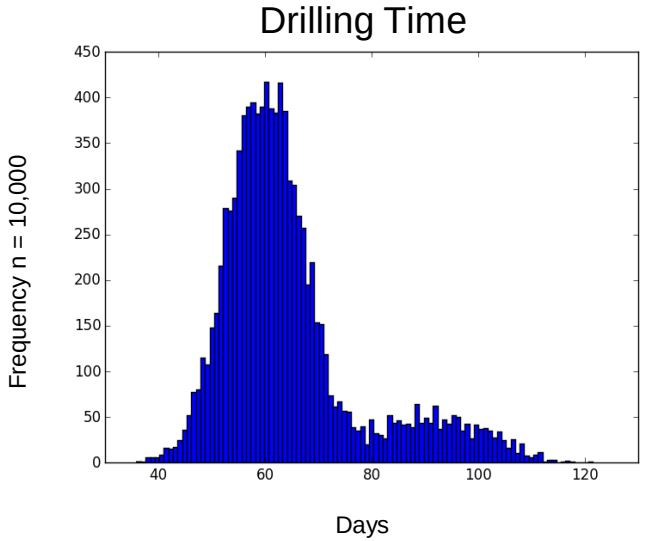
Consecutive swatches of land are scanned in 2D or 3D to provide an understanding of the geology of the area. Costs are driven by the dificulty of the terrain and technology used. Analysis and processing costs added.



Exploratory Well

Drilling Time

The major cost of well drilling is the labor and equipment. Drilling prices are quoted in “dayrates,” a contract cost per day.



Exploratory Well

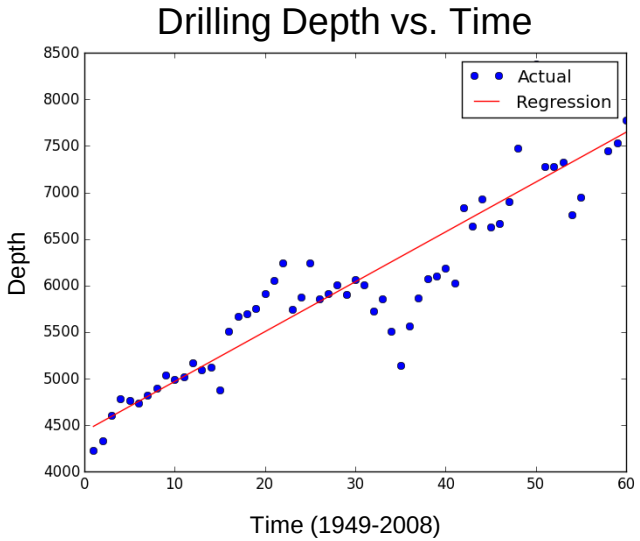
Drilling Depth

A driver for numerous other exploratory costs, the depth of well is important to estimate.

2016 Estimate

Point Forecast: 8075 ft

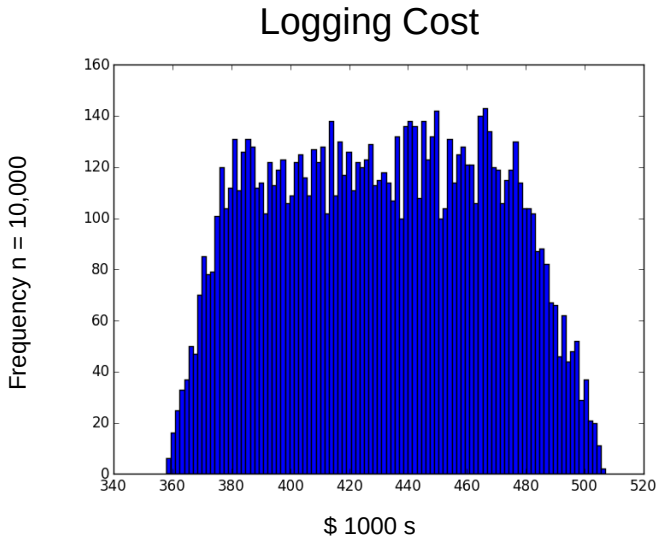
95% Interval:{7819 ft, 8332 ft}



Logging

Mud Analysis

During and following exploratory drilling, samples of mud and extracted rock are continuously analyzed. The cost of these geological tests are based on drilling depth.

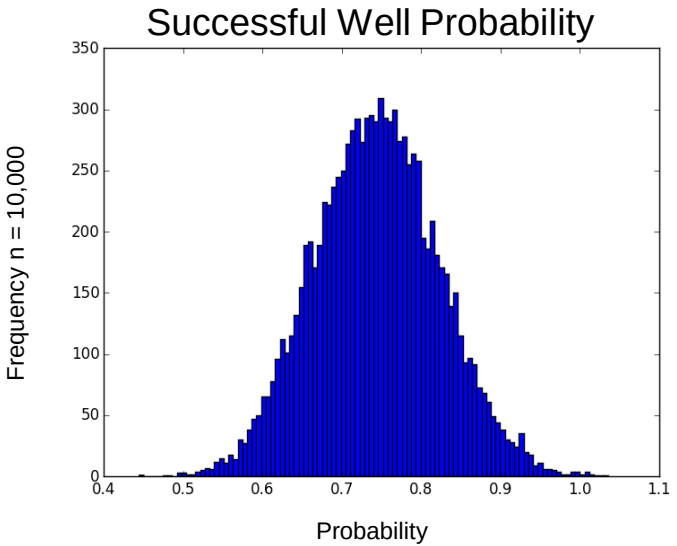


Probability of Finding Oil

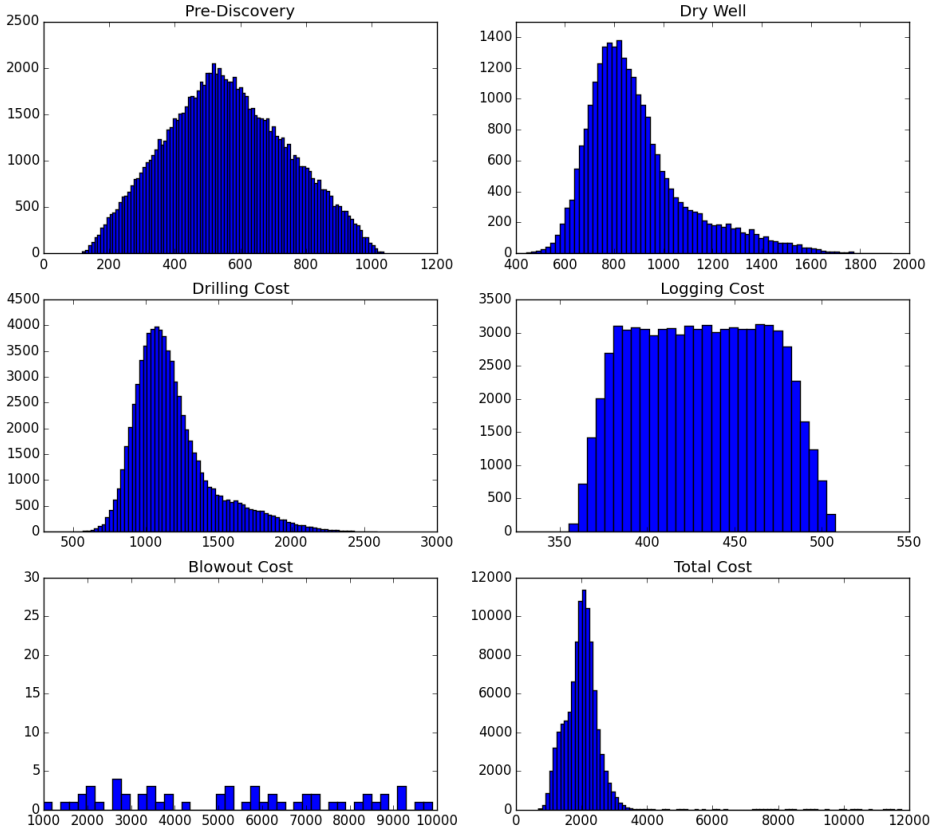
Dry Hole Risk

Distinct chance of not finding any extractable crude oil.

$$P_{Successful\ Well} = P_{Hydrocarbons} \times P_{Reservoir} \times P_{Seal} \times P_{Structure}$$



Exploration Simulation



Simulation Parameters
-100,000 Iterations
-0.049% Blowout Probability

Total Cost Descriptive Statistics
min: 691.92
mean: 1988.20
max: 11747.77
std dev: 468.40
var: 219401.02


Production
Simulation

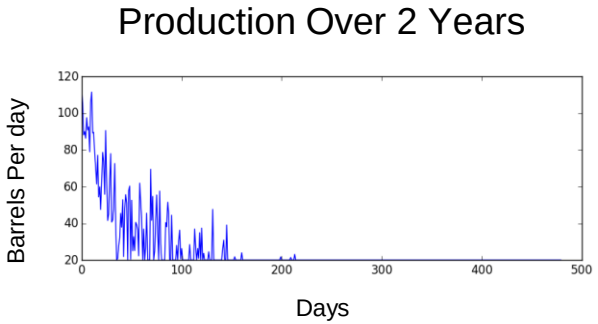
Production Duration

Exponential Decline

As crude oil is extracted, the pressure from the water content decreases resulting in decline production

$$q_t = q_i e^{-Dt}$$

q_t = *Rate of production at time t*
q_i = *Initial rate of production*
D = *decline rate %*
t = *time*

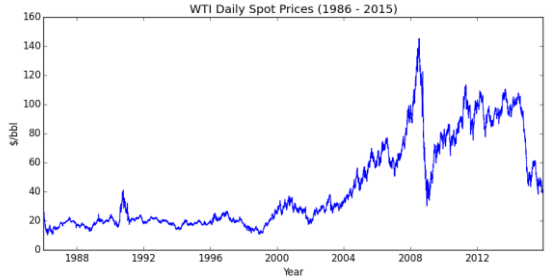


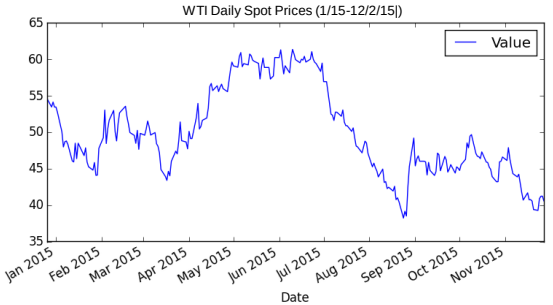

```
def prodQt(t):
    qi = np.random.triangular(85,96,125)
    D = np.random.triangular(0.005,0.012, 0.05)
    minimum = 20.0
    qt = qi*exp(-1*D*t)
    return qt
```

Oil Price

West Texas Intermediate

Produced oil will be marked to the WTI spot price on a daily basis, and discounted to the present at the 10 year Treausry rate

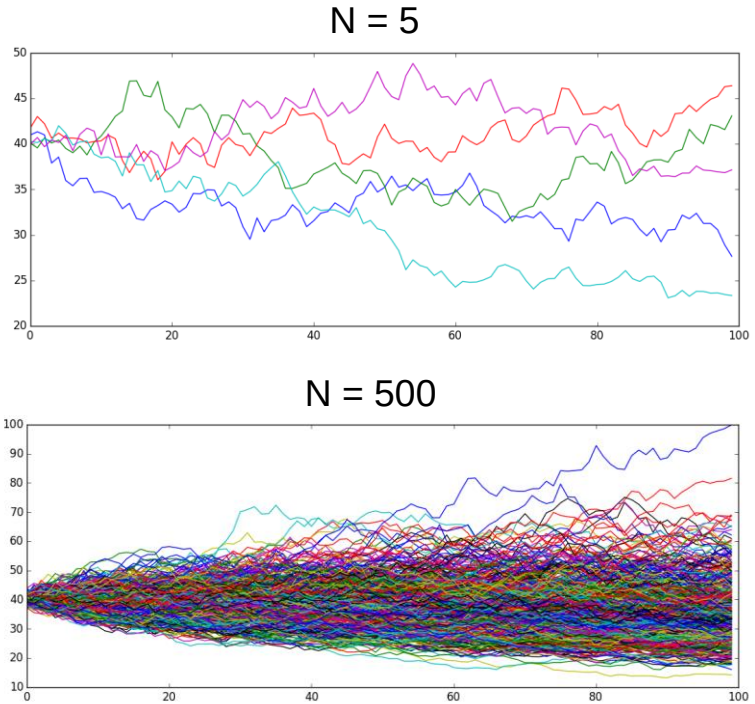




Oil Price

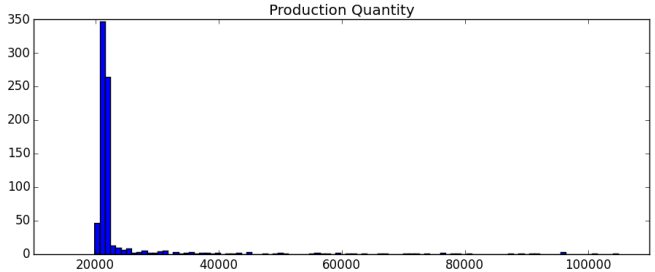
Geometric Random Walk

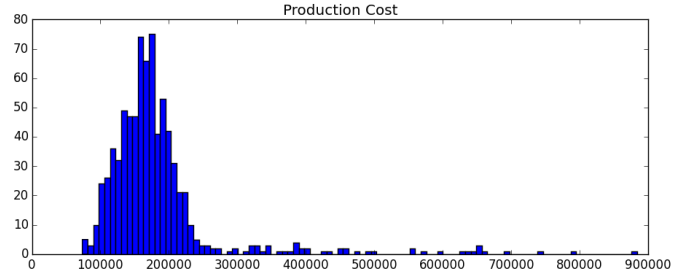
Due to the discussed recent changes, this model was implemented to simulate the price path of the asset in a conservative manner

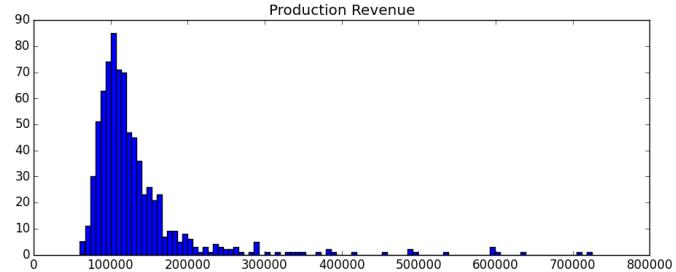


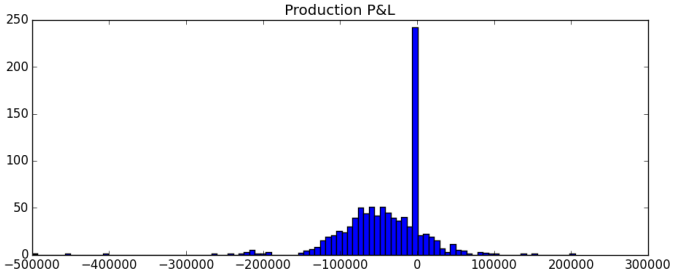
$-2,198,004

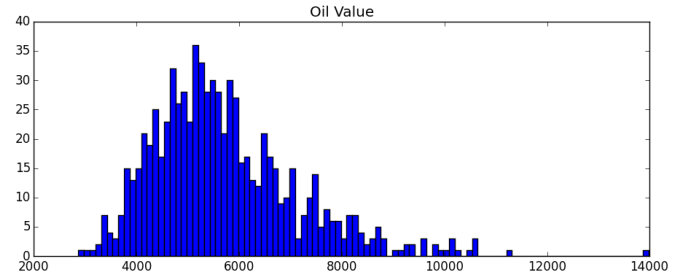
Final Simulation

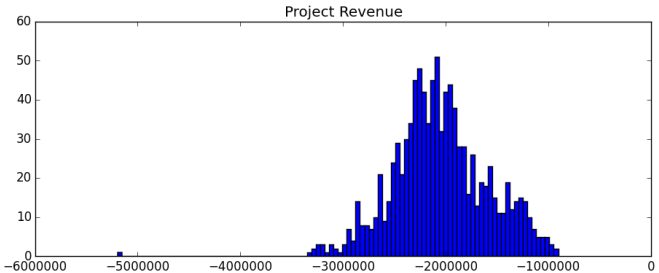




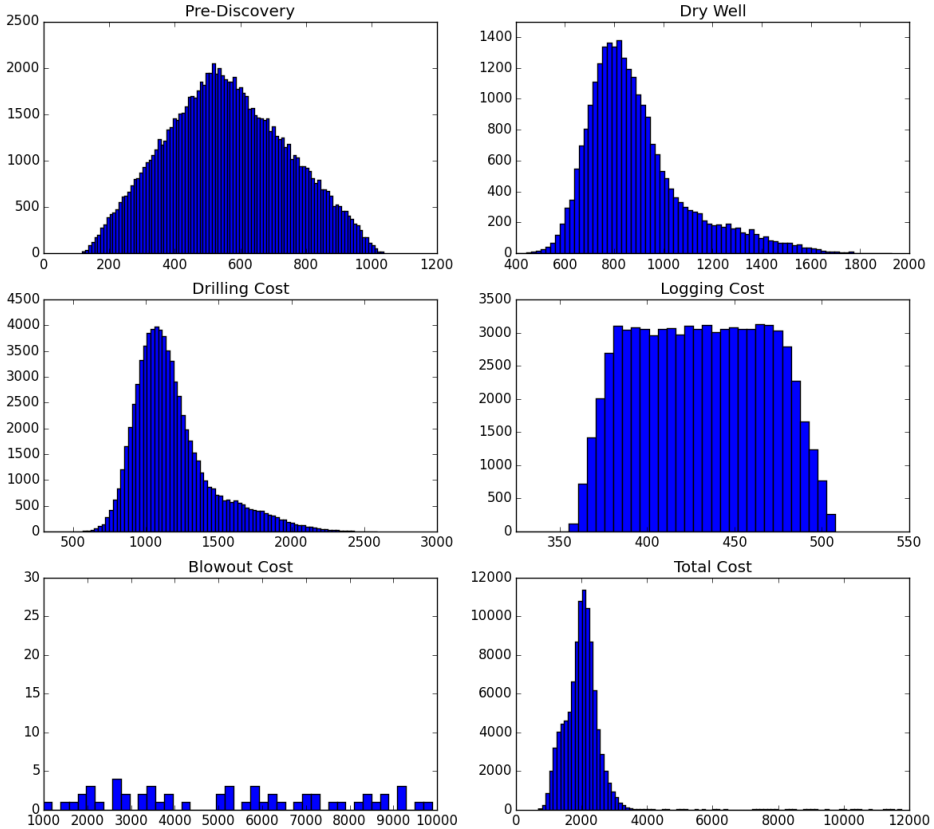








Exploration Simulation



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Conclusion

Exploration is EXPENSIVE
Optimizing for oil price at T=0 as wel as years of production still made profit unlikely

Production Decline is FAST
Increasing the time of production greatly does not contribute much to revenue

Dry Holes
In the current economy, any project that is started is likely better off not finding oil

Oil Prices
Using previous “stable” values of $80 and $100 resulted in much more favorable estimates

Simulation Parameters
Computational limits made simulating past 1500 iterations for the final Monte Carlo challenging

Assumptions
This model assumes to know things many years away. Is best used on an ongoing basis.

Thanks!

Any questions ?