Oil and Gas Exploration and Production – Phase 2

RFP #: TF – F3.H2

Simulation & Risk - Homework 2

Sanya Goyal, Kian Kamyab, Kimberly Keiter, Sam Koshy (L), Samantha Mazzeo

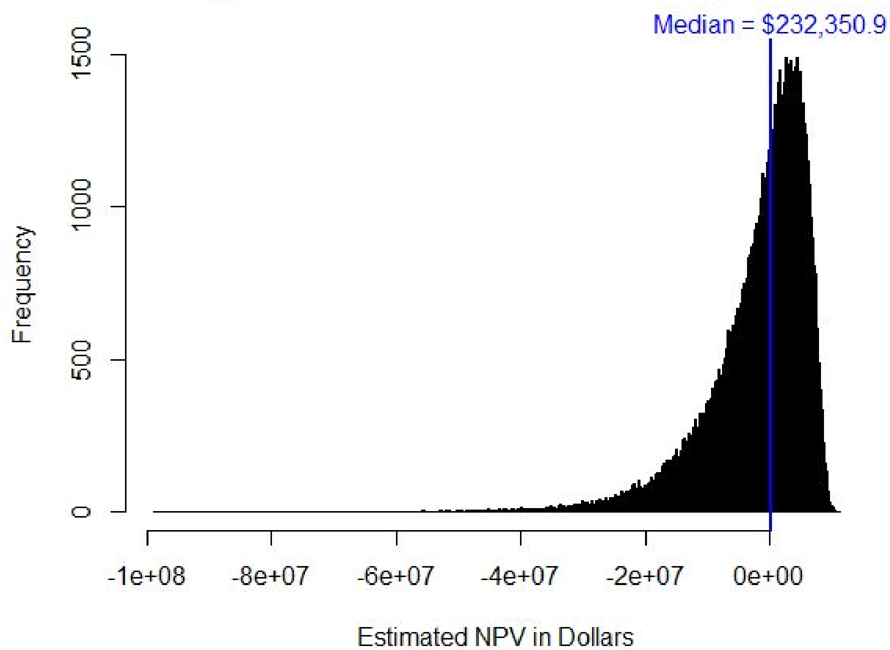
22nd November, 2017

Executive Summary

We were tasked by the Compagnie Pétrolière et Gazière, Inc. (the Company) to simulate the distributions of the cost of a single crude oil well in 2018 and the net present value (NPV) of a single crude oil well in 2040. We utilized a kernel density estimator to simulate the distribution of the cost of a single crude oil well in 2018 by projecting costs from 2006 onward. This distribution was used as a fixed cost value for the calculation of the NPV. We calculated a final distribution of the NPV of a single crude oil well using the distribution of projected drilling costs in 2018 along with the projected distributions of barrels produced and price per barrel.

The projected NPV of a crude oil well has a highly left-skewed distribution, representing a 48.7% probability of losses. The median NPV for 23 years of operations is $232,351. The simulated distribution of NPV is illustrated below in Figure 1.

Figure 1. Net Present Value of a Single Crude Oil Well



Results and Recommendations

The distribution of expected NPV is left-skewed with a median value of $232,351 for 23 years of operation. Furthermore, there is a 48.7% probability that the NPV of a single crude oil well will be negative. This is a disproportionately risky operation with very low probability of windfall gains and high probability of massive losses. The first quartile NPV for the operation is estimated to be a loss of $5.27 million.

We recommend that the Company hedge downside risk by using a crude oil price swap with a fixed receipt that is at least $56.57 above the “AEO2016 Reference” index price. This will ensure that the Company breaks even at the first quartile of NPV. Alternatively, the Company can invest in increasing production by at least 2191 barrels. This will also ensure that the Company breaks even at the first quartile of NPV.

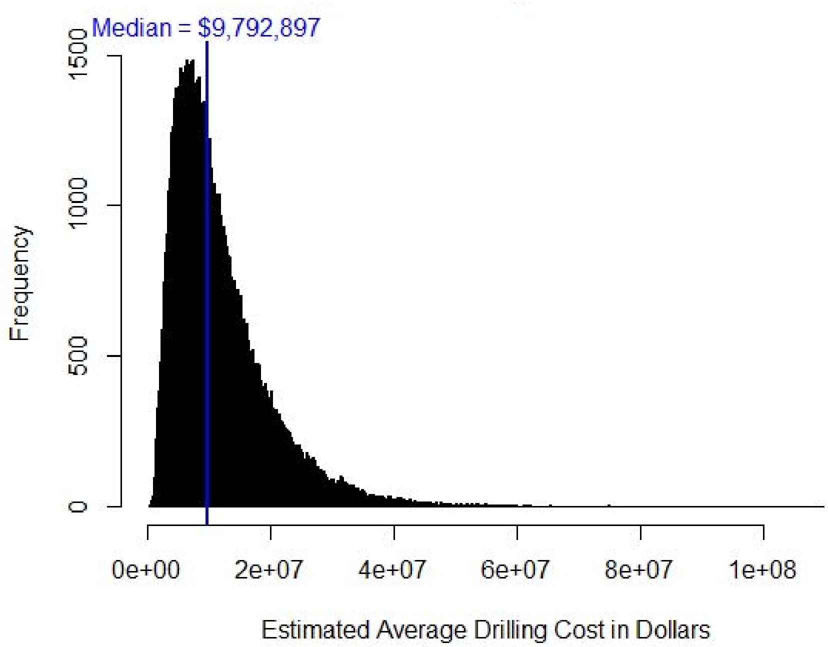
We strongly discourage conducting the crude oil production without a price hedge at a level equal to or above $56.57 over “AEO2016 Reference”, or changing oil well machinery such that it boosts production by at least 2,191 barrels per year. A strategy combining both the price hedge and increased production would be ideal.

Analysis

Cost

To simulate drilling costs, we used a kernel density estimator to fit a distribution on historical cost data. Bandwidth for the kernel density estimator was calculated using the Sheather and Jones selection method. The distributions of cost for each year from 2006 to 2018 were simulated through 100,000 trials using the probability density function of the kernel density estimator. This yielded a median 2018 drilling cost of a single crude oil well in 2018 of $9.79 million. The distribution of simulated 2018 drilling cost is illustrated in Figure 2.

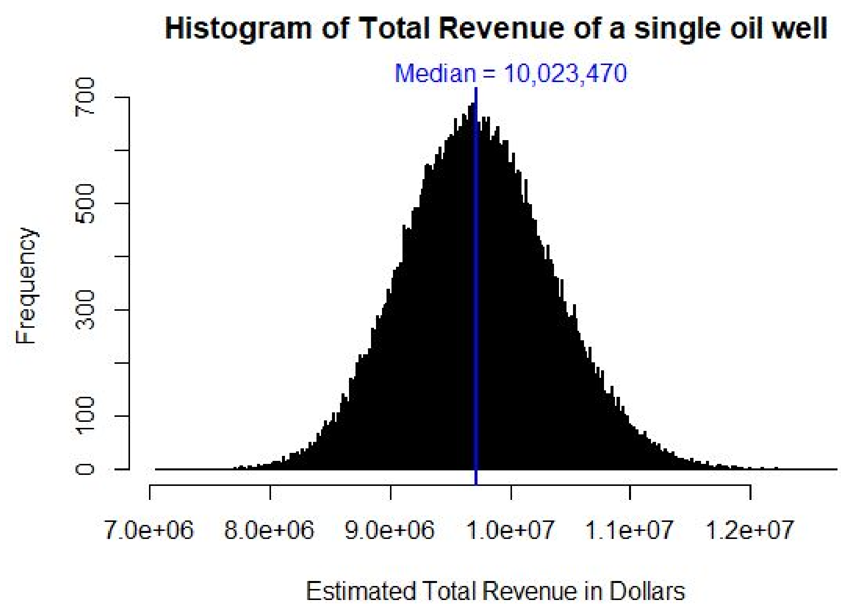
Figure 2. Histogram of Drilling Costs of a Single Crude Oil Well in 2018



Revenue

The distribution of simulated total revenue of a single crude oil well was estimated by simulating both per well production and price per barrel for each year from 2018 through 2040. Price per barrel was simulated by fitting historical high, low, and reference per barrel oil prices to a triangular distribution in 100,000 trials. Production per well was also simulated using a triangular distribution in 100,000 trials with high, low, and modal production parameters provided by the Company. Simulated values of price per barrel and well production were multiplied element-wise to generate a simulated distribution of total revenue, illustrated in Figure 3. Simulated median revenue is $10.02 million for a single crude oil well.

Figure 3. Histogram of Total Revenue of a Single Crude Oil Well



Net Present Value

The Company requested the distribution of a modified NPV by simulating the distribution of revenue of a single crude oil well from 2018 to 2040 and limiting cost to the distribution of fixed single-well costs in 2018. No discounting or variable costs were assessed otherwise. This yielded a simulated distribution of NPV illustrated in Figure 1, with a median NPV of $232,351 and a 48.7% probability of a negative NPV.

Next Steps

We recommend that the Company mitigate the significant financial risk of constructing and operating a single crude oil well from 2018 to 2040 by exploring hedging strategies or expanding production. The simulated distribution of NPV indicates that the Company should explore price swaps with a fixed receipt at least $56.57 above the “AEO2016 Reference” price. Alternatively, the Company can assess the feasibility of increasing production from a single crude oil well by 2,191 barrels per year. Either strategy would shift the Company’s expected distribution of NPV to the right, limiting the magnitude of downside-risk.

Appendix

R Code.

```
library(xlsx)
PriceProj <- read.xlsx('C:/Users/Sam Koshy/Desktop/MSA - Fall/502/Fall 3/Simulation &
Risk/HW/2/Analysis_Data.xlsx', 1, startRow = 4)
DrillingCost <- read.xlsx('C:/Users/Sam Koshy/Desktop/MSA - Fall/502/Fall 3/Simulation &
Risk/HW/2/Analysis_Data.xlsx', 2, startRow = 4)

# Drilling Costs from 1991-2006 - 16 obs
cost <- DrillingCost[31:46, 5]
library(graphics)
library(ks)
cost
PriceProj
hist(cost,breaks=8)

#Simulation using kernel density estimator#
new.density <- density(cost, bw='SJ-ste')
new.density
set.seed(9385)
rate.value=matrix(exp(rkde(fhat=kde(cost, h=0.08908), n=12*100000)),nrow=100000)
co=2238.6*1000*apply(rate.value,1,prod)

##Cost of Drilling in 2018
hist(co, breaks=500, main=paste("Histogram of Drilling Cost for 2018"),
        xlab = 'Estimated Average Drilling Cost in Thousands of Dollars', ylab = 'Frequency')
median(co)
abline(v=median(co), col='blue', lwd=2)
mtext("Median = $9,792,897", at=9792897, col="blue")

#Barrels
library("triangle")
Barrels= matrix(rltriangle(n=23*100000, a=3285, b=5475, c=4015),nrow=100000)

#Price
Price=rep(0,100000)
for (i in rep(1:23)){
  Pricei=matrix(rltriangle(n=100000, a=PriceProj[i,3], b=PriceProj[i,2], c=PriceProj[i,4]),nrow=100000)
  Price = cbind(Price,Pricei)
}
Price=Price[,2:24]
#Revenue
Revenue=Barrels*Price
TotRev= apply(Revenue,1,sum)
```

```
hist(TotRev, breaks=500, main=paste("Histogram of Total Revenue of a single oil well"),
        xlab = 'Estimated Total Revenue in Thousands of Dollars', ylab = 'Frequency')
median(TotRev)
abline(v=median(TotRev), col='blue', lwd=2)
mtext("Median = 10,023,470", at=10023470, col="blue")

##Net Present Value
NPV=TotRev-co
hist(NPV, breaks=500, main=paste("Histogram of Net Present Value of a single oil well"),
        xlab = 'Estimated NPV in Thousands of Dollars', ylab = 'Frequency')
mean(NPV)
median(NPV)
abline(v=median(NPV), col='blue', lwd=2)
mtext("Median = $232,350.9", at=232350.9, col="blue")
sum(NPV<(0))/100000
quantile(NPV)

####################################################################################
#Oil Swap Price Recommendation, trial and error for different values of "buffer" (iterate all codes
#below for different values of buffer object, current value is optimized)
#Price
buffer=56.5645
Price1=rep(0,100000)
for (i in rep(1:23)){
  Pricei=matrix((PriceProj[i,4]+buffer),nrow=100000)
  Price = cbind(Price,Pricei)
}
Price1=Price1[,2:24]
#Revenue
Revenue1=Barrels*Price1
TotRev1= apply(Revenue1,1,sum)
#NPV
NPV1=TotRev1-co
hist(NPV1, breaks=500, main=paste("Histogram of Net Present Value of a single oil well"),
        xlab = 'Estimated NPV in Thousands of Dollars', ylab = 'Frequency')
mean(NPV1)
quantile(NPV1)

####################################################################################
##Production boost recommendation  (iterate all codes
#below for different values of boost object, current value is optimized)
#Barrels
boost=2191
Barrels2= matrix(rltriangle(n=23*100000, a=3285+boost, b=5475+boost, c=4015+boost),nrow=100000)
#Revenue
Revenue2=Barrels2*Price
TotRev2= apply(Revenue2,1,sum)
#NPV
```

```
NPV2=TotRev2-co
hist(NPV2, breaks=500, main=paste("Histogram of Net Present Value of a single oil well"),
        xlab = 'Estimated NPV in Thousands of Dollars', ylab = 'Frequency')
mean(NPV2)
quantile(NPV2)
```