Oil and Gas Exploration and Production – Phase 1

RFP #: TF – F3.H1

Simulation & Risk - Homework 1

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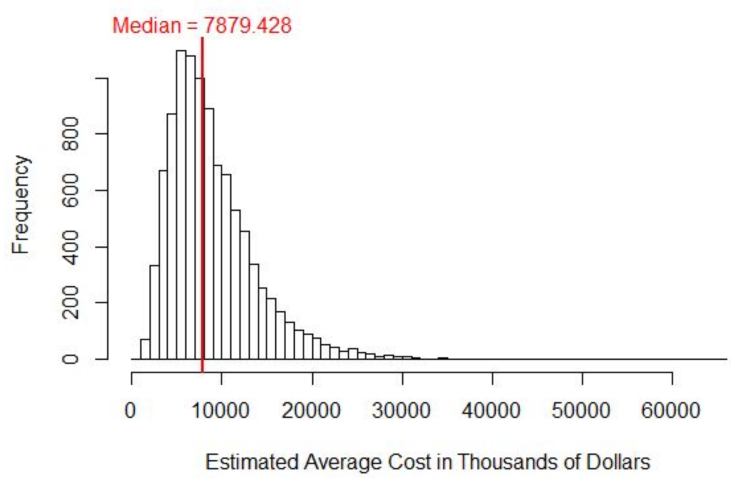
Executive Summary

The Price Analysis team of Compagnie Pétrolière et Gazière, INC. tasked us with predicting drilling costs for 2018 by comparing simulations from a normal distribution and a kernel density estimation. To perform this analysis, we made the assumption that the geometric changes of drilling costs are equally represented by the individual geometric changes of crude oil, natural gas, and dry wells, and we only considered costs from the years 1991-2006. After verifying these rate values follow a normal distribution, we conducted the simulations to project the drilling costs over twelve years.

Using the simulation conducted from the normal distribution, we found the median drilling cost of 2018 to be $7,879,428, which indicates that the probability of estimated costs being higher than this value is 50%, shown in Figure 1. Similarly, using the simulation conducted from the kernel density estimator, we found the median drilling cost of 2018 to be $7,112,335, which indicates that the probability of estimated costs being higher than this value is 50%. Since the simulations produced similar projected costs, we recommend Compagnie Pétrolière et Gazière, INC. use the normal distribution for future simulations because it is a simpler method. Additionally, since these projected costs are dramatically higher than the average drilling cost in 2006 ($2,279,800), we recommend that the Company make preparations to account for this possible future change.

Figure 1. 2018 Estimated Cost Distribution Under Normality Assumption

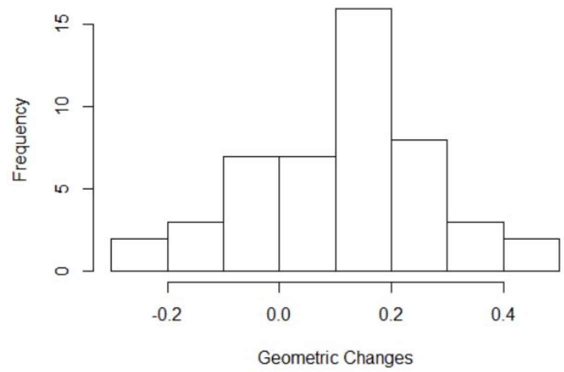


Analysis and Results

Verification of Normality

Before running the two simulations, we verified that the geometric changes of the drillings costs for the 1991-2006 historical data followed a normal distribution by first observing its distribution (Figure 2). Based on this plot, the data approximately follows a normal distribution; however, to more formally verify this assumption, we created a QQ plot (Figure A in the Appendix) and conducted the Anderson-Darling test. Since the values on the QQ plot follow a linear pattern and the Anderson-Darling results failed to reject the assumption of normality (at an alpha level of 0.01).

Figure 2. Distribution of Annual Geometric Changes from 1991-2006



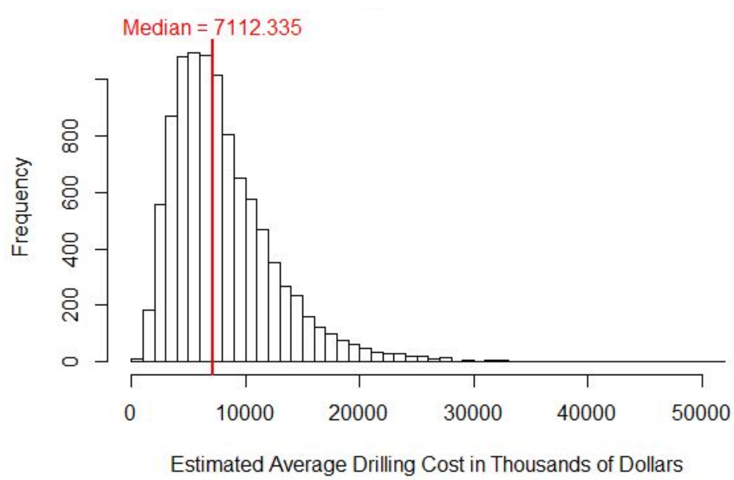
Simulations

After verifying the assumption of normality, we projected the drilling costs for 2018 by using two methods of simulating the geometric change: the normal distribution and the kernel density estimation.

In order to project drilling costs using the first method, 10,000 values were randomly drawn from a normal distribution generated by the mean and standard deviation of the historical geometric changes. By assuming an initial drilling cost as the average drilling cost for 2006 ($2,279,800), we were able to calculate the projected distribution of the drilling cost for the year 2018 by following a simple interest rate formula. This distribution is displayed in Figure 1. The median drilling cost is labeled at approximately $7,879,428, which indicates that the probability of estimated costs being higher than this value is 50%.

To project drilling costs using the second method, 10,000 values were randomly drawn from the kernel density estimator function generated by the approximate bandwidth (0.06627) of the historical geometric changes. Similar to the first method, we assumed an initial drilling cost as the average drilling cost for 2006 and followed a simple interest rate formula to produce the projected drilling cost distribution for 2018, which is shown in Figure 3. The median drilling cost is labeled at approximately $7,112,335, which indicates that the probability of estimated costs being higher than this value is 50%.

Figure 3. 2018 Estimated Cost Distribution Under Kernel Density Estimation

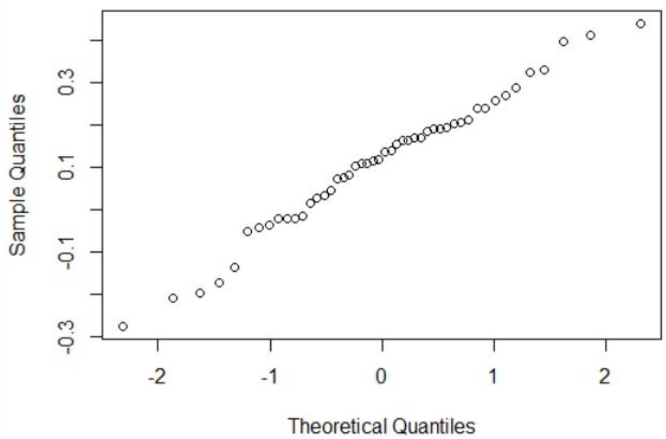


Next Steps

Using the geometric changes of the drilling costs for the 1991-2006 historical data, we were able to project the rates twelve years by implementing two simulation methods. The normal distribution and kernel density estimation methods simulated the geometric change over time, which led to two projected distributions of drilling costs for 2018. Since these results were very similar, we recommend that Compagnie Pétrolière et Gazière, INC. utilize the normal distribution method because it provides a simpler approach. However, when looking into creating these projections in the future, we recommend continuously using both methods to see if there is a change or advantage to one method over the other.

Appendix

Figure A. QQ Plot of Annual Geometric Changes from 1991-2006



R Code.

```
library(xlsx)
# The values in Columns E:G from rows 35:50 should be saved in H5:H52 of 'Drilling Cost' sheet
PriceProj <- read.xlsx('C:/Users/Samantha/Documents/IAA Fall/Simulation & Risk/Homework 1/Analysis_Data.xlsx', 1, startRow = 3)
DrillingCost <- read.xlsx('C:/Users/Samantha/Documents/IAA Fall/Simulation & Risk/Homework 1/Analysis_Data.xlsx', 2, startRow = 3)

# Drilling Costs from 1991-2006 - 16 obs each, 48 total
cost <- DrillingCost[2:49, 8]

library(graphics)
library(ks)

# Histogram of the annual geometric changes from 1991 to 2006 #
hist(cost, breaks = 50, main='Histogram of Geometric Changes', xlab = 'Geometric Changes')

geomMean <- mean(cost)
geomSD <- sd(cost)

# Checking normality assumption for annual geometric changes #
library(nortest)
qqnorm(cost)  # qq plot #
ad.test(cost) # anderson-darling test for normality #

# This is the average cost from 2006 #
y = 2279.8
```

```
# Simulation under normality assumption #
P0 <- 2279.8
set.seed(5396)
estAvgGeo <- rnorm(n=10000, mean=geomMean, sd=geomSD)
Pt <- P0*(1 + estAvgGeo)

x <- 5397
for (i in 1:12) {
  set.seed(x)
  estAvgGeo <- rnorm(n=10000, mean=geomMean, sd=geomSD)
  Pt <- Pt*(1 + estAvgGeo)
  i = i + 1
  x = x + 1
}

hist(Pt, breaks=50, main='2018', xlab='Estimated Average Cost in Thousands of Dollars')
abline(v = median(Pt), col="red", lwd=2)
median(Pt)
mtext("Median = 7864.926", at=median(Pt), col="red")

#Simulation using kernel density estimator#

new.density <- density(cost, bw='SJ-ste')
new.density
set.seed(9385)
rate.value=matrix((1+rkde(fhat=kde(cost, h=0.06627), n=12*10000)),nrow=12)
co=2279.8*apply(rate.value,2,prod)

hist(co, breaks=50, main=paste("Histogram of Average Geometric Return for 2018"),
     xlab = 'Estimated Average Drilling Cost in Thousands of Dollars', ylab = 'Frequency')
median(co)
abline(v=median(co), col='red', lwd=2)
mtext("Median = 7096.171", at=7127.055, col="red")
```