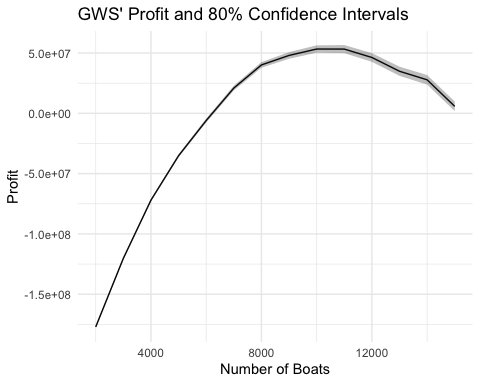
MET 616 Assignment 4

JingjianGao

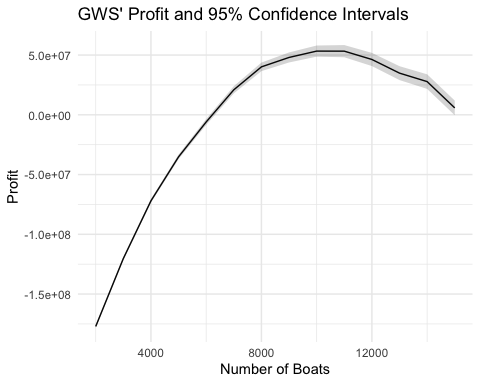
2023-11-29

## Question 1

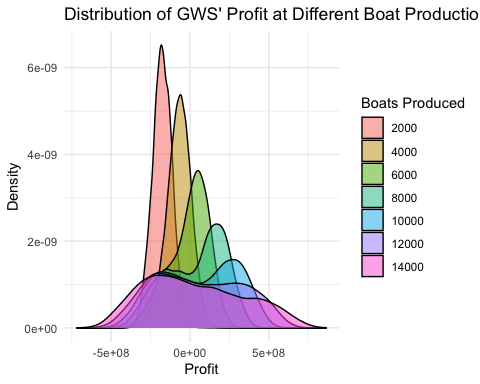
# Code from Assignmtn #3  
library(ggplot2)  
  
set.seed(100)  
mean\_fixed\_cost <- 300e6   
std\_dev\_fixed\_cost <- 60e6   
retail\_price\_initial <- 150000 # Initial retail price  
retail\_price\_final <- 70000 # Final retail price after two years  
min\_variable\_cost <- 77000   
most\_likely\_variable\_cost <- 90000   
max\_variable\_cost <- 100000   
n\_simulations <- 10000  
  
# The Demand ranges and their probabilities  
demand\_ranges <- list(c(2000, 5000), c(5001, 10000), c(10001, 14000), c(14001, 15000))  
probabilities <- c(0.35, 0.40, 0.20, 0.05)  
  
  
simulation\_demand <- function() {  
 index <- sample(1:length(demand\_ranges), size = 1, prob = probabilities)  
 return(sample(demand\_ranges[[index]][1]:demand\_ranges[[index]][2], size = 1))  
}  
  
simulation\_profit <- function(n\_boats) {  
 fixed\_costs <- rnorm(n\_simulations, mean\_fixed\_cost, std\_dev\_fixed\_cost)  
 variable\_costs <- runif(n\_simulations, min\_variable\_cost, max\_variable\_cost)  
 profits <- numeric(n\_simulations)  
   
 for (i in 1:n\_simulations) {  
 demand <- simulation\_demand()  
 units\_sold\_at\_high\_price <- min(n\_boats, demand)  
 units\_sold\_at\_low\_price <- max(n\_boats - demand, 0)  
 total\_variable\_cost <- variable\_costs[i] \* n\_boats  
 total\_cost <- fixed\_costs[i] + total\_variable\_cost  
 total\_revenue\_high <- retail\_price\_initial \* units\_sold\_at\_high\_price  
 total\_revenue\_low <- retail\_price\_final \* units\_sold\_at\_low\_price  
 profits[i] <- total\_revenue\_high + total\_revenue\_low - total\_cost  
 }  
   
 return(profits)  
}  
  
# a)  
  
# Function to calculate confidence intervals  
calculate\_ci <- function(data) {  
 mean\_profit <- mean(data)  
 std\_dev\_profit <- sd(data)  
 n <- length(data)  
   
 se <- std\_dev\_profit / sqrt(n)  
 z\_80 <- qnorm(0.9) # For 80% CI  
 z\_95 <- qnorm(0.975) # For 95% CI  
   
 ci\_80 <- z\_80 \* se  
 ci\_95 <- z\_95 \* se  
   
 return(list(mean\_profit = mean\_profit, ci\_80 = ci\_80, ci\_95 = ci\_95))  
}  
  
boats <- seq(2000, 15000, by = 1000)  
profits\_data <- sapply(boats, function(boats\_count) {  
 profits <- simulation\_profit(boats\_count)  
 cis <- calculate\_ci(profits)  
 c(mean\_profit = cis$mean\_profit, ci\_80 = cis$ci\_80, ci\_95 = cis$ci\_95)  
})  
  
profits\_df <- data.frame(Boats = boats, t(profits\_data))  
  
# Plot  
ggplot(profits\_df, aes(x = Boats, y = mean\_profit)) +  
 geom\_line() +  
 geom\_ribbon(aes(ymin = mean\_profit - ci\_80, ymax = mean\_profit + ci\_80), alpha = 0.3) +  
 labs(  
 title = "GWS' Profit and 80% Confidence Intervals",  
 x = "Number of Boats",  
 y = "Profit"  
 ) +  
 theme\_minimal()



ggplot(profits\_df, aes(x = Boats, y = mean\_profit)) +  
 geom\_line() +  
 geom\_ribbon(aes(ymin = mean\_profit - ci\_95, ymax = mean\_profit + ci\_95), alpha = 0.2) +  
 labs(  
 title = "GWS' Profit and 95% Confidence Intervals",  
 x = "Number of Boats",  
 y = "Profit"  
 ) +  
 theme\_minimal()



# b)  
  
simulation\_profit\_specific <- function(n\_boats, n\_simulations) {  
 profits <- simulation\_profit(n\_boats)  
 return(data.frame(Boats = rep(n\_boats, n\_simulations), Profit = profits))  
}  
  
boats\_to\_simulate <- c(2000, 4000, 6000, 8000, 10000, 12000, 14000)  
n\_simulations <- 10000  
  
profits\_data <- lapply(boats\_to\_simulate, function(boats\_count) {  
 simulation\_profit\_specific(boats\_count, n\_simulations)  
})  
  
combined\_data <- do.call(rbind, profits\_data)  
  
# Density plots  
ggplot(combined\_data, aes(x = Profit, fill = factor(Boats))) +  
 geom\_density(alpha = 0.5) +  
 labs(  
 title = "Distribution of GWS' Profit at Different Boat Production Levels",  
 x = "Profit",  
 y = "Density"  
 ) +  
 scale\_fill\_discrete(name = "Boats Produced") +  
 theme\_minimal()



# c)  
  
# i)  
calculate\_mean\_profit <- function(n\_boats) {  
 profits <- simulation\_profit(n\_boats)  
 return(mean(profits))  
}  
  
boat\_levels <- seq(2000, 15000, by = 1000)  
  
mean\_profits <- sapply(boat\_levels, calculate\_mean\_profit)  
  
optimal\_boats\_mean\_profit <- boat\_levels[which.max(mean\_profits)]  
  
optimal\_boats\_mean\_profit

## [1] 11000

# ii) 10th percentile  
calculate\_10th\_percentile <- function(n\_boats) {  
 profits <- simulation\_profit(n\_boats)  
 return(quantile(profits, 0.1))  
}  
  
percentile\_10th <- sapply(boat\_levels, calculate\_10th\_percentile)  
  
optimal\_boats\_10th\_percentile <- boat\_levels[which.max(percentile\_10th)]  
  
optimal\_boats\_10th\_percentile

## [1] 5000

# iii)  
  
simulation\_profit <- function(n\_boats) {  
 fixed\_costs <- rnorm(n\_simulations, mean\_fixed\_cost, std\_dev\_fixed\_cost)  
 variable\_costs <- runif(n\_simulations, min\_variable\_cost, max\_variable\_cost)  
 profits <- numeric(n\_simulations)  
 profitable\_simulations <- rep(0, n\_simulations)   
   
 for (i in 1:n\_simulations) {  
 demand <- simulation\_demand()  
 units\_sold\_at\_high\_price <- min(n\_boats, demand)  
 units\_sold\_at\_low\_price <- max(n\_boats - demand, 0)  
 total\_variable\_cost <- variable\_costs[i] \* n\_boats  
 total\_cost <- fixed\_costs[i] + total\_variable\_cost  
 total\_revenue\_high <- retail\_price\_initial \* units\_sold\_at\_high\_price  
 total\_revenue\_low <- retail\_price\_final \* units\_sold\_at\_low\_price  
 profit <- total\_revenue\_high + total\_revenue\_low - total\_cost  
   
 if (profit >= 50e6) {  
 profitable\_simulations[i] <- 1   
 }  
 profits[i] <- profit  
 }  
   
 return(list(profits = profits, profitable\_simulations = profitable\_simulations))  
}  
  
calculate\_probability\_profit\_50m <- function(n\_boats) {  
 results <- simulation\_profit(n\_boats)  
 profitable\_simulations\_count <- sum(results$profitable\_simulations)  
 probability\_profit\_50m <- profitable\_simulations\_count / n\_simulations  
 return(probability\_profit\_50m)  
}  
  
boat\_levels <- seq(2000, 15000, by = 1000)  
  
prob\_50m <- sapply(boat\_levels, calculate\_probability\_profit\_50m)  
  
prob\_50m

## [1] 0.0002 0.0044 0.0469 0.1895 0.3783 0.5121 0.5411 0.5372 0.5175 0.4863  
## [11] 0.4781 0.4663 0.4444 0.4221

## Question 2

# a)  
library(DEoptim)

## Loading required package: parallel

##   
## DEoptim package  
## Differential Evolution algorithm in R  
## Authors: D. Ardia, K. Mullen, B. Peterson and J. Ulrich

calculate\_expected\_profit <- function(x) {  
 a <- x[1]  
 b <- x[2]  
 trials <- 10000  
 total\_profit <- numeric(trials)  
 for (i in 1:trials) {  
 value\_a <- qlnorm(runif(1), meanlog = log(2 \* a), sdlog = log(3 \* a))  
 value\_b <- qlnorm(runif(1), meanlog = log(1.6 \* b), sdlog = log(2 \* b))  
 total\_value <- value\_a + value\_b  
   
 total\_profit[i] <- max(0, total\_value \* 0.85 - a - b)  
 }  
   
  
 expected\_profit <- -mean(total\_profit)  
 return(expected\_profit)  
}  
  
lower <- c(1, 1)  
upper <- c(100, 100)  
  
result <- DEoptim(calculate\_expected\_profit, lower, upper)

## Iteration: 1 bestvalit: -1250994397.047353 bestmemit: 83.959968 90.772267  
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optimal\_investment <- result$optim$bestmem  
optimal\_profit <- -result$optim$bestval   
  
print(paste("Optimal Investment in Company A:", optimal\_investment[1]))

## [1] "Optimal Investment in Company A: 95.1028149713372"

print(paste("Optimal Investment in Company B:", optimal\_investment[2]))

## [1] "Optimal Investment in Company B: 78.2626422060159"

print(paste("Expected Profit:", optimal\_profit))

## [1] "Expected Profit: 1335836998602.69"

# b)  
calculate\_expected\_profit\_with\_constraint\_tax\_updated <- function(x) {  
 a <- x[1]   
 b <- x[2]   
 trials <- 10000  
 total\_profit <- numeric(trials)  
   
 for (i in 1:trials) {  
 value\_a <- qlnorm(runif(1), meanlog = log(2 \* a), sdlog = log(3 \* a))  
 value\_b <- qlnorm(runif(1), meanlog = log(1.6 \* b), sdlog = log(2 \* b))  
   
 total\_value <- value\_a + value\_b  
   
 profit\_before\_tax <- total\_value - a - b  
   
 if (profit\_before\_tax > 100e6) {  
 positive\_profit\_tax <- (profit\_before\_tax - 100e6) \* 0.15  
 total\_profit[i] <- max(0, profit\_before\_tax - positive\_profit\_tax)  
 } else {  
 total\_profit[i] <- max(0, profit\_before\_tax)  
 }  
 }  
  
 expected\_profit <- -mean(total\_profit)   
   
 after\_tax\_60m <- 60e6 / 0.85  
 prob\_after\_tax\_60m <- sum(total\_profit >= (after\_tax\_60m - a - b)) / trials  
   
 constraint <- ifelse(prob\_after\_tax\_60m >= 0.95, 0, 1e6)   
 return(expected\_profit + constraint)   
}  
  
lower <- c(1, 1)   
upper <- c(100, 100)  
  
result\_constraint\_tax\_updated <- DEoptim(calculate\_expected\_profit\_with\_constraint\_tax\_updated, lower, upper)

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optimal\_investment\_constraint\_tax\_updated <- result\_constraint\_tax\_updated$optim$bestmem  
optimal\_profit\_constraint\_tax\_updated <- result\_constraint\_tax\_updated$optim$bestval   
  
  
print(paste("Optimal Investment in Company A (with updated tax & constraint):", optimal\_investment\_constraint\_tax\_updated[1]))

## [1] "Optimal Investment in Company A (with updated tax & constraint): 89.7339916063437"

print(paste("Optimal Investment in Company B (with updated tax & constraint):", optimal\_investment\_constraint\_tax\_updated[2]))

## [1] "Optimal Investment in Company B (with updated tax & constraint): 61.7392707148977"

print(paste("Expected Profit (with updated tax & constraint):", optimal\_profit\_constraint\_tax\_updated))

## [1] "Expected Profit (with updated tax & constraint): -204075063448.83"