Final Paper 400

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Monte-Carlo Estimations of Pharmaceutical Student Loan Debt Default

In a paper from the American Journal of Pharmaceutical Education, Mattingly and Ulbrich conducted a simulation on net income for pharmaceutical students. They report that the average amount of money borrowed by pharmaceutical students in 2014 is around 144,718 USD. That estimated amount has increased to around 179,514 USD, as reported by recent graduates in 2020. This finding was the main inspiration for our study. As university students ourselves, we wanted to understand how the industry uses Monte Carlo methods to determine the best estimates for making profit off student loans. In this paper, we will be analyzing the average amount that a bank would lose from defaults on loans. We will then use monte carlo simulations to determine the minimum interest rate to ensure that the bank won't lose money. We will then use Monte Carlo to see if we can find an interest rate that would lower the chance of losing money to 5%.

Methodology:

We used monte carlo estimation to predict a bank's exposure to pharmaceutical student loan default. The total exposure to loss was calculated as the number of loans multiplied by the default rate multiplied by the default loss.

Defining our parameters, our simulated average loan was 144,000 USD, while our default rate and loss were 7% and 174,115 USD, respectively. Our MC estimation consisted of 1000 iterations with the defined parameters, resulting in calculated (actual) and monte carlo estimations of total losses of 1,218,805,000 USD and 1,218,471,744 USD, respectively.

Equation: $Loss = n_{loans} * Default_{Rate} * Default_{loss}$

This equation is the original one we used, and it doesn't attempt to get profit. It's just calculating the amount the bank would lose if it charged 0% interest.

The calculated results were found as described above, while the MC estimation of the student loan exposure was a result of sampling the given parameters iteratively, creating vectors of student default debt consisting of either 0 or the estimated loss: $174,115. Each of these vectors of student default were 10,000 rows long, and our MC estimate consisted of taking 1000 of these 10,000 student samples.

Our next step was to find the minimum interest rate required for the bank to expect 0 losses. We used another MC estimation of 100 iterations to predict the minimum interest rate required for 0 expected losses, and we found the interest from simulation and from the actual equation to be 0.091 and 0.09100993, respectively. Clearly, our monte-carlo estimates were good representations of the underlying theoretical population.

Our equation for profit: $Gain * (1 - Default_{Rate}) - (Default_{Loss} * Default_{Rate}) = Profit$

We want to test for profit of $0, to check for minimum interest that the bank has to charge

$Gain * (1 - Default_{Rate}) - (Default_{Loss} * Default_{Rate}) = 0$

$Gain = (Default_{Loss} * Default_{Rate})/(1 - Default_{Rate})$

This is the equation used by the bank to calculate the interst rate necessary to generate profit.

We can calculate interest as Interest = Gain/Loan

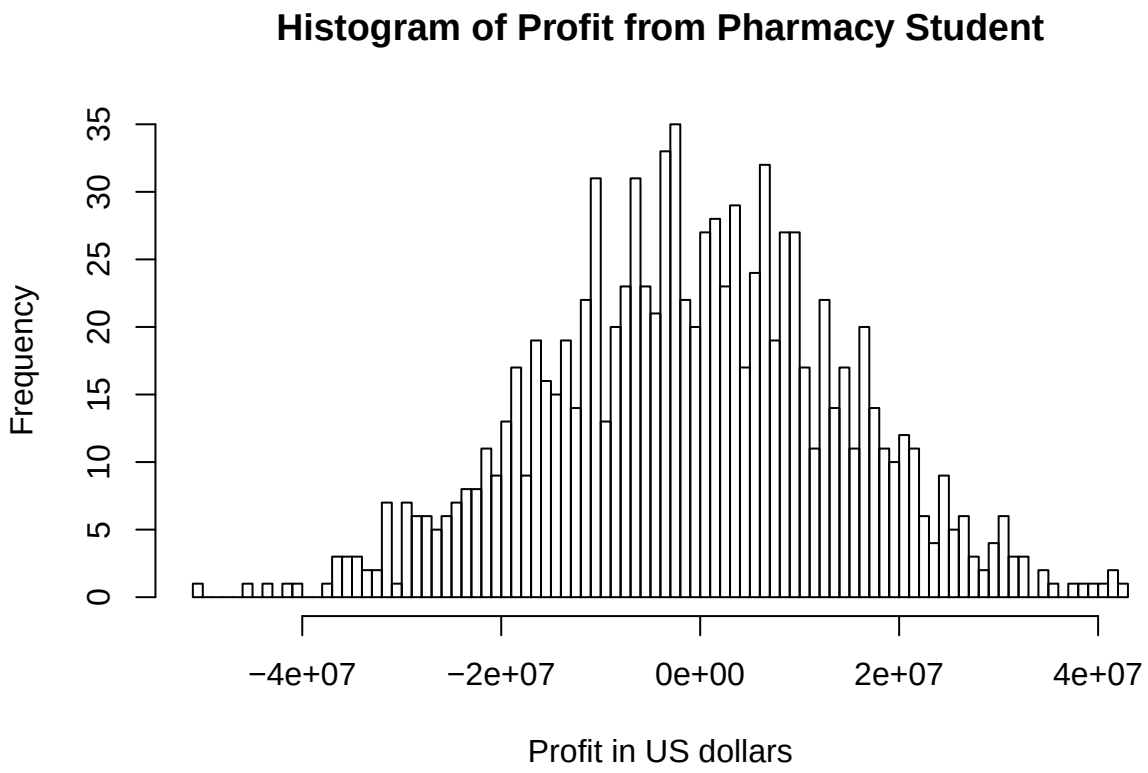
```
cat("Interest from Simulation:", interest, "\n")
```

```
## Interest from Simulation: 0.091
```

```
cat("Interest from Equation", -(dloss * drate / (1-drate))/loan)
```

```
## Interest from Equation 0.09100993
```

```
# Minimum Interest?
hist(simu,breaks=100,xlab="Profit in US dollars",
   main="Histogram of Profit from Pharmacy Student")
```




```
cat("Interest from Equation: ", eq)
```

```
## Interest from Equation:  0.09251709
```

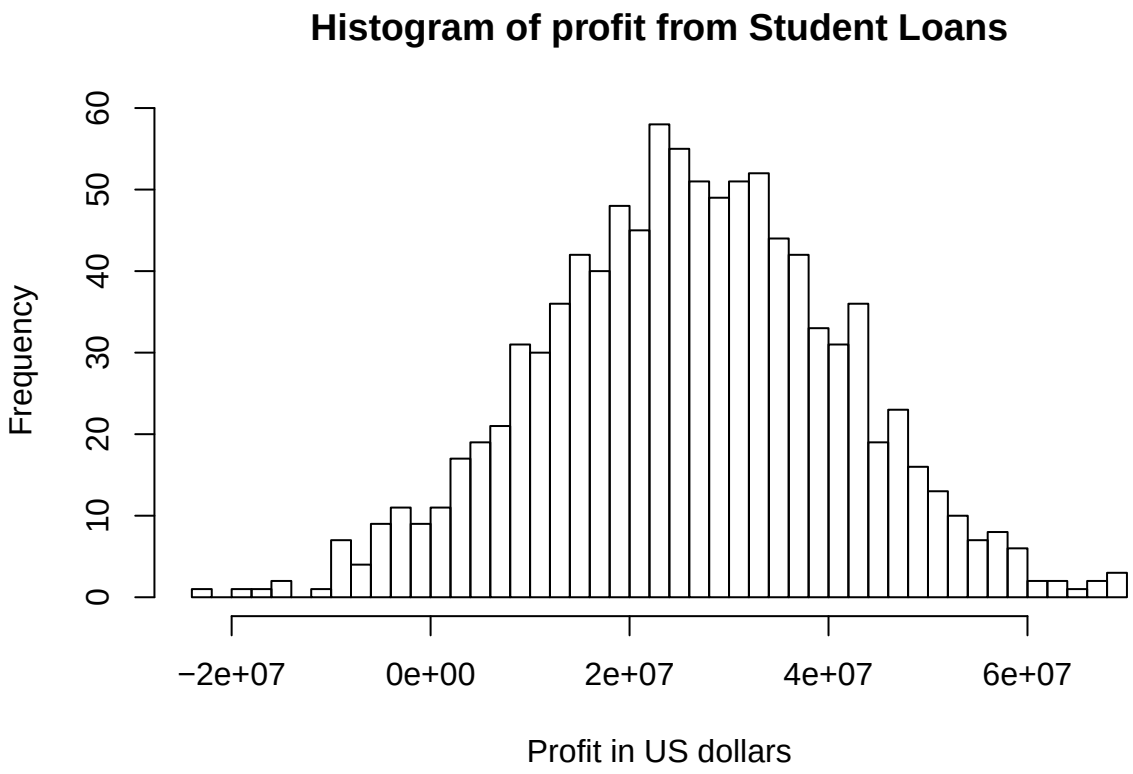
```r
set.seed(400)

#when we have to include the percent taht student can't pay the moneyback

interest <- 0.0    # Start with a 0% interest

result <- 0

while (TRUE){
    interest <- interest + 0.001 # Each interation increases interest by 0.1% until the result is great
    result <- replicate(B,{
                        temp <- sample(c(loan*interest,dloss), n_loans, prob = c(1-drate,drate), replac
                        sum(temp)
    })

    if (mean(result <= 0)<=0.05){break} # Test if the scenarios where profit was < 0 represent the 5% o
}
```

```r
cat("Interest from Simulation: ", interest)
```

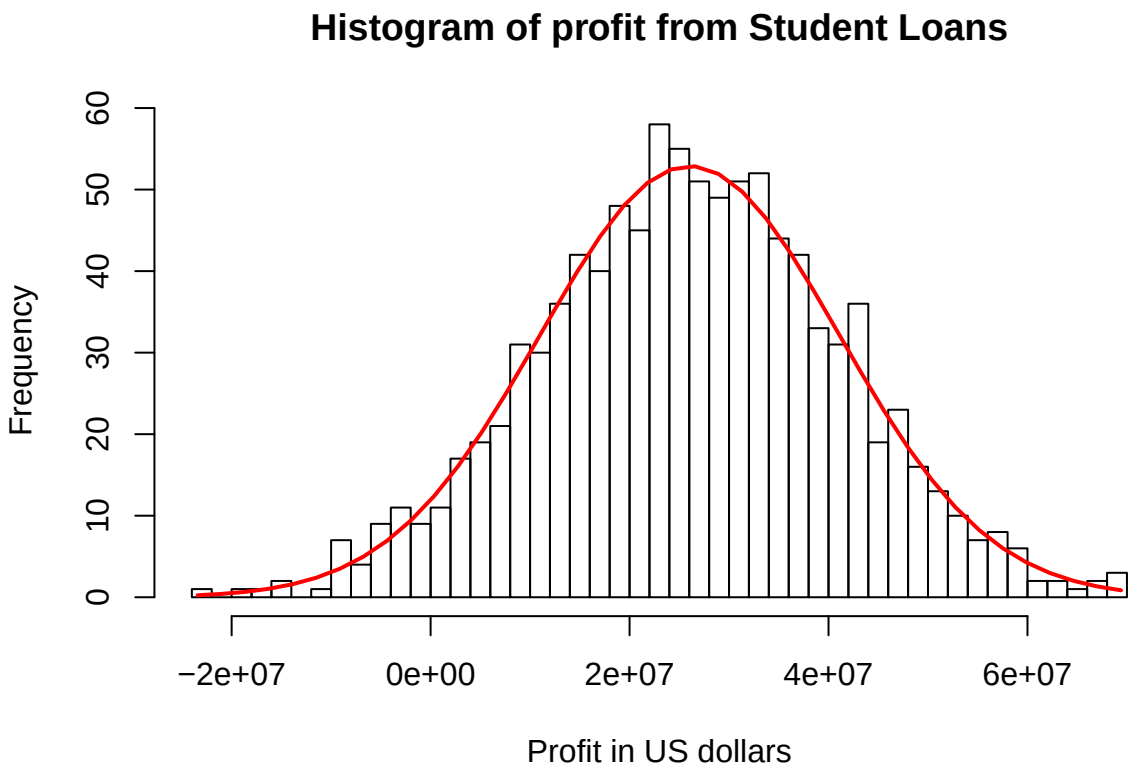
```
## Interest from Simulation:  0.093
```

We can see that the equation is providing us with an interest rate of 9.25%, while the simulation is providing us with an interest rate of 9.3%. We can also see from the graph below that the distribution is normal.

```r
hist(simu2,breaks=50,xlab="Profit in US dollars",
   main="Histogram of profit from Student Loans")
```




```
set.seed(400)

h<-hist(simu2, breaks=50, xlab="Profit in US dollars",
   main="Histogram of profit from Student Loans")
x<-seq(min(simu2),max(simu2),length=40)
y<-dnorm(x,mean=mean(simu2),sd=sd(simu2))
y <- y*diff(h$mids[1:2])*length(simu2)
lines(x, y, col="red", lwd=2)
```



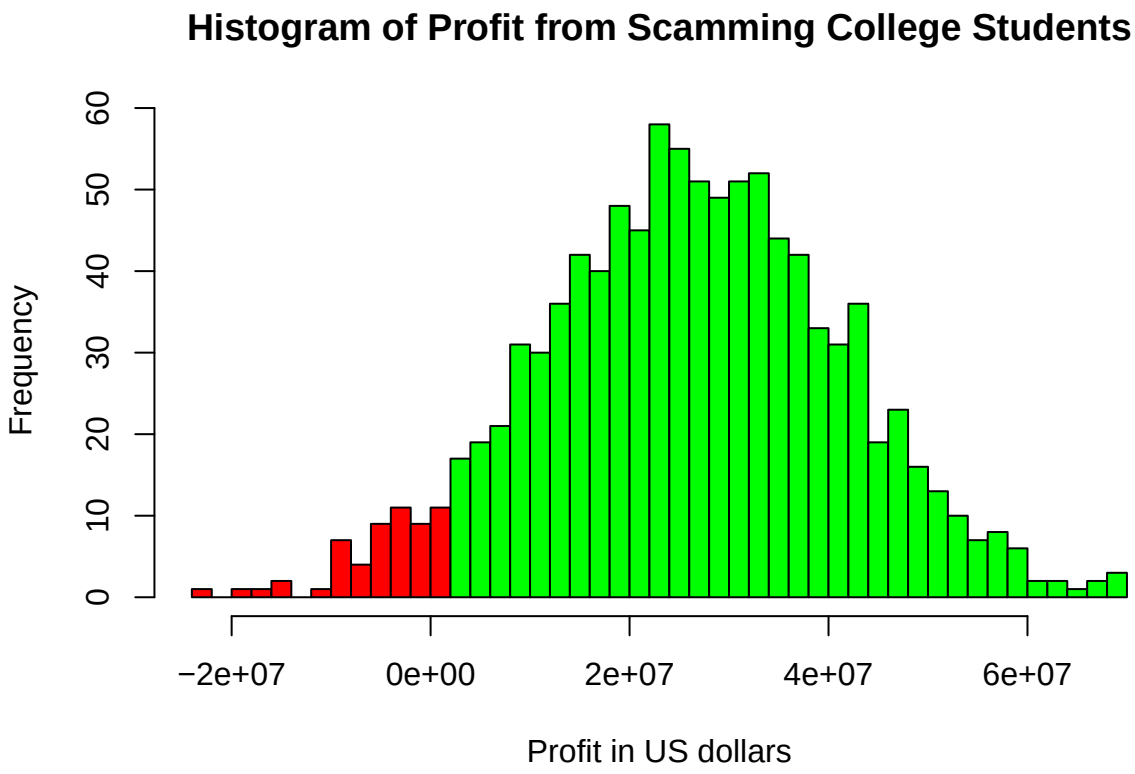
Our final job to visually represent what a 5% likelihood looks like in terms of a standardized distribution is to find the 5th quantile. This is simply done by using "pnorm". Our 5th Quantile is going to be approximately .04.

```
quantile_val <- pnorm(0.05,mean = mean(simu2), sd = sd(simu2))
cat("5th Quantile:",quantile_val )
```

```
## 5th Quantile: 0.04213294
```

Our final histogram represents the probability of losses for a 9.2% interest rate. In total, the bank would have a 5% chance of losing money. The red part of the histogram represents the iterations resulting in losses, while the green part represents the iterations that were profitable.

```
# This project was based of code found here :
# https://www.kaggle.com/darioabadie/2008-loan-crisis-monte-carlo-method

ccat = cut(h$breaks, c(-Inf, quantile_val, Inf))
plot(h, col=c("red","green")[ccat],xlab="Profit in US dollars",
   main="Histogram of Profit from Scamming College Students")
```



Conclusion:

The interest rate of 9.2% seems to be incredible high but according to "Student Loan Interest Rate", the interest rate for student loan usually is between 2.75% to 5.30% but for the private student (including pharmacy student), the student loan can be between 3.34% to 12.99%.3 Hence, 9.2% interest rate from our simulation seem to be reasonable to conclude as a solution. But we also want to see why the interest rate for student loan is extremely high come pare with other loans, so we test out our simulation with different variable such as default loss, default rate, and among of loan that the bank gives out. Base, on our result, we can conclude that all the interest rate is depending on the default rate, if the banks want to make their interest become lower, they must decrease their default rate. This could be done by being more forgiving in the repayment process. The banks could also try to lower monthly payment that make all student can effort all the loan, this is a reason why some degree or some bank have over 10 to 20 years of loan.

Works Cited:

1 Mattingly, T. J., 2nd, & Ulbrich, T. R. (2017). Evaluating the Changing Financial Burdens for Graduating Pharmacists. American journal of pharmaceutical education, 81(7), 5990. https://doi.org/10.5688/ajpe8175990

2 Nykiel, T. (2021, May 21). What is the average pharmacist student loan debt? NerdWallet. Retrieved December 16, 2021, from https://www.nerdwallet.com/article/loans/student-loans/average-pharmacist-student-loan-debt

3 Smith, J. (2021, December 1). Student Loan Interest Rates of December 2021. Investopedia. Retrieved December 16, 2021, from https://www.investopedia.com/student-loan-interest-rates-5069743

4. Github: 2008 Loan Crisis- Monte Carlo Method https://www.kaggle.com/darioabadie/2008-loan-crisis-monte-carlo-method