Are Initial Public Offerings *Truly* Underpriced?

A Case Study by Monte Carlo Simulation

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September 15, 2005

1 Questions

The text and the academic literature claim that initial public offerings (IPOs) are severely underpriced. This is discussed as a pricing anomaly and is often used to directly attack the efficiency of financial markets. After all, 17%+ average returns in 1 day! Everyone should be millionaires! Why we not all millionaires? To see why we should all be millionaires within one years time frame, calculate what $V_0 = \$10,000$ would grow to if we invested in only one IPO each week.

$$V_{\text{year end}} = V_0 \times (1.17)^{52}.$$

OK, we are game. Let us invest. Below we will calculate the "true" realizable return to just such a strategy.

1. Download IPO data from CRSP.[1]
2. Determine the distribution of returns for each week covered by the database. That is, for each week, you want to record the underpricing return for each IPO issued in that month. This is your empirical distribution for IPO returns for that month.

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[1]The Center for Research in Security Prices, University of Chicago Graduate School of Business. URL: http://www.crsp.chicagogsb.edu/

3. Assume that you were to devise the investment strategy of buying one IPO every week and selling to realize the underpricing return. Each week, randomly select one of the returns from that week's distribution.
4. Calculate this particular investment sample path's realized final value.

$$V_{\text{year end}} = V_0 \times (1 + R_1) \times (1 + R_2) \times \cdots \times (1 + R_{52}).$$

5. Repeat steps #3 and #4 for a total of 5000 sample paths. This gives us an empirical distribution of the possible returns from following our strategy.
6. Calculate the mean and the median for the empirical distribution derived in step #5. Are they the same? Are they close? Explain what is going on.
7. Compare your actual investment returns (from step #6) with the theoretical expected returns as calculated with equation 1. Do you find the book's coverage of the IPO underpricing fair and/or adequate? Should you trust everything you read in a graduate level finance book?

2 Data

We downloaded our IPO data from CRSP. The dimension of the matrix is 5784 $\times$ 15 and the data contains 15 relevant variables of all IPOs with period spanning January 1975 through December 2000.

3 Analysis

We use R[2] for our Monte Carlo simulation. First, let us set the working directory.

```
> setwd("C:/Research/IPO Case/")
```

After we have downloaded the IPO data from CRSP, we determine the distribution of returns for each week covered by the database. That is, for each week, we record the underpricing return for each IPO issued in that month. This is our empirical distribution for IPO returns for that month. Now, read-in the IPO data.

```
> data <- read.table(file="ipodata2.txt",header=TRUE)
> dim(data) # check the dimension of the data matrix
[1] 5783    2
> names(data)
[1] "ipodate" "IR"
```

Check the summary statistics of the dataset.

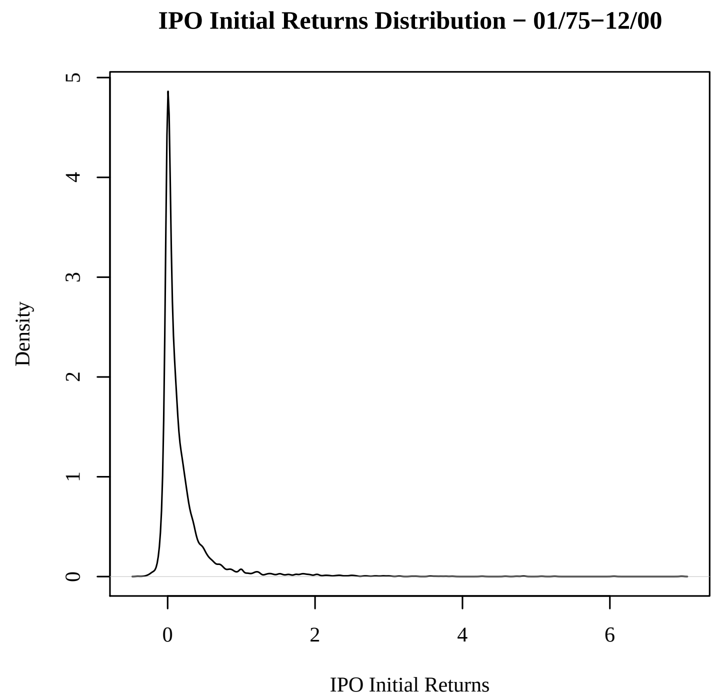
```
> summary(data)
    ipodate              IR
 Min.   :197501   Min.   :-0.40385
 1st Qu.:198703   1st Qu.: 0.00000
 Median :199310   Median : 0.06579
 Mean   :199203   Mean   : 0.19528
 3rd Qu.:199612   3rd Qu.: 0.21736
 Max.   :200012   Max.   : 6.97500
```

[2]The R Project for Statistical Computing: `http://www.r-project.org`.

Plot the density of IPO initial return by "Kernel Density Plot" function.

```
> pdf(file = "ipo_chart.pdf",width = 5, height = 5, family = "Times", pointsize = 10)
> plot(density(data[,2]),xlab="IPO Initial Returns", ylab="Density",
+     main="IPO Initial Returns Distribution - 01/75-12/00")
> dev.off()
```

Figure 1: IPO initial return's kernel probability density.



Sort the data such that each row contains one specific month.

```
> table(data[,1]) # number of monthly average returns per each month

197501 197502 197506 197509 197510 197601 197602 197605 197606 197607 197609
     1      1      1      1      2      4      1      2      2      1      4
197611 197612 197701 197702 197703 197704 197705 197706 197710 197712 197804
     1      3      3      1      3      2      1      2      2      3      1
...

> nrows <- length(table(data[,1])) # no. effective months
> ncols <- max(table(data[,1])) # highest number of monthly IPOs
> data.box <- matrix(NA,nrows,ncols) # a matrix with months and average return entries
> rownames(data.box)<- names(table(data[,1])) # name the rows with date
```

Fill-in the data box.

```
> for(i in 1:nrow(data.box)){
+
+     # Indicator of a specific month
+     ind <- as.numeric(rownames(data.box)[i] == data[,1])
+
+     # No. of availabe initial IPO returns in a specific month
+     cut <- sum(ind)
+
+     # Index the corresponding returns of a specific month
+     data1 <- data[,2]
+     for(j in 1:length(data1)){if(ind[j]==0){data1[j]<-NA}} # index other months' returns
+
+     # Skim-off the debris to leave with returns of a specific month
+     row <- rbind(na.omit(data1))
+
+     # Fill-in each row of the data box
+     data.box[i,1:cut] <- row
+
+     }
```

Let us write an IPO investment function.

```
> ipo.fund <- function(v0, data=data.box, dur, sims){
+
+     # Matrix for values of investment over time per simulation
+     result <- matrix(NA,sims,(dur+1))
+     result[,1] <- v0 # seed-money for the first column
+
+     for(i in 1:sims){
+
+         # For each simulation pick "dur" many random months
+         sim.months <- sample(rownames(data),dur)
+
+         for(j in 1:dur){
+
+ #   Assume that you were to devise the investment strategy of buying one IPO
+ #   every month and selling to realize the underpricing return.  Each month,
+ #   randomly select one of the returns from that months distribution.
+
+             # Pick the returns of a specific month
+             sim.returns <- c(t(as.numeric(rownames(data)==sim.months[j]))%*%data)
+             sim.returns <- na.omit(sim.returns) # skim-off the debris
+             r <- sample(sim.returns,1) # randomly pick one IPO stock of the month
+
+ #   Calculate this particular investment sample paths realized final value.
+ #
+ #   Vyear end = V0 * (1+R1) * (1+R2)*  * (1+R52)
+
+             result[i,(j+1)] <- result[i,j]*(1+r) # value of the investment cumulates
+
```

```
+             }
+
+         }
+
+     returns <- result/result[,1] -1 # caculate returns over time per simulation
+     Er <- round(mean(returns[,(dur+1)]),2) # mean return across the simulations
+     Medr <- round(median(returns[,(dur+1)]),2) # median return across the simulations
+     EV <- round(mean(result[,(dur+1)]),2) # mean value across the simulations
+     MedV <- round(median(result[,(dur+1)]),2) # median value across the simulations
+
+     # Returns distribution chart by kernel density plot
+     if(sims>1){
+         plot(density(returns[,(dur+1)]),xlab="IPO initial returns (100%)",ylab="Density",
+         main=paste(sims,'x-Simulated IPO Initial Returns over',dur,'Period'))
+         }
+
+     cat("\n")
+     cat(paste("The investment results with",sims,"simulation(s)\n"))
+     cat(paste("with $",v0,"seed-money after",dur,"month(s) are:\n"))
+     cat(" --------------------------------------------------------\n")
+     cat(paste("Mean value = $",EV," with",Er,"mean return and\n"))
+     cat(paste("Median value = $",MedV," with",Medr,"median return\n"))
+
+     }
```

Run the simulation once over 52 months with a US$10,000 seed-money.

```
> ipo.fund(v0=10000,data=data.box,dur=52,sims=1)

The investment results with 1 simulation(s)
with $ 10000 seed-money after 52 month(s) are:
---------------------------------------------------------
Mean value = $ 988494.72  with 97.85 mean return and
Median value = $ 988494.72  with 97.85 median return
```

We repeat steps #3 and #4 for a total of 5000 sample paths. This gives us an empirical distribution of the possible returns from following our strategy. We run the simulation 5000 times over 52 months with US$10,000 seed-money. Also, we calculate the mean and the median for the empirical distribution derived in step #5.

```
> ipo.fund(v0=10000,data=data.box,dur=52,sims=5000)

The investment results with 5000 simulation(s)
with $ 10000 seed-money after 52 month(s) are:
---------------------------------------------------------
Mean value = $ 472242.4  with 46.22 mean return and
Median value = $ 292084.17  with 28.21 median return
```

With mean significantly higher than median, the simulated investment results exhibit a right-skewed distribution. We compare your actual investment returns (from step #6) with the theoretical expected returns.

$$V_{\text{year end}} = 10000 \times (1.17)^{52} = 35,128,921.$$

We have a 3,511.89 (= $35,128,921/10000 - 1$) theoretical net return versus a 46.22 simulated mean! Thus, our simulated mean return is overwhelmingly insignificant relative to the theoretical return.

4 Conclusion

In conclusion, we witness a severely right-skewed return distribution thus it would be biased-up to solely mention the mean of the initial returns when describing the overall distributional characteristics of the initial returns of IPO issues. Since the median is significantly lower than the mean it is advised that we pay caution when accepting the mean estimate from a right-skewed distribution. Without mentioning the skewness, the average argument assuming distributional symmetry will lead to a misleading bottom line. In this regards, we may as well discount the overly-exaggerated justification of underpricing of IPO issues.

Figure 2: A right-skewed probability density.