Risk Management & Financial Modelling A1

Question 1

I retrieved the data from the 'Monthly' tab, column of 'IBM continuously compounded total return'. Each index of the continuously compounded return is denoted by r_i for $i = 1, , n$ with $n = 1104$.

Part A: Using 'Question 1.a)' tab:

Excel functions
To calculate **min**, I used the function = MIN($r_1, , r_n$). This gives the lowest number within $r_1, ..., r_n$, which is -0.30368. To calculate **max**, I used the function = MAX($r_1, , r_n$). This gives the highest number within $r_1, ..., r_n$, which is 0.30291. To calculate **median**, I used the function = MEDIAN($r_1, , r_n$).This gives the middle number in the range $r_1, ..., r_n$, and if there are two numbers that are the 'middle' number, it will the average of the two values. For this series of returns, the median is 0.010186.

** Manual calculations**

To calculate **mean**, I will use the following formula with $n = 1104$, with the formula

$$E(R) = \frac{\sum_{i=1}^{n} r_i}{n}$$

with r_i for $i = 1, ..., 1104$ and a mean of 0.010610882.

To calculate **variance**, I used the formula

$$Var(R) = \frac{\sum_{i=1}^{n} (r_i - \bar{r})}{n-1}$$

I broke up the calculation into 2 steps. One column first computes $(E(R) - \bar{r})$, and the second column calculates the squared of that $(E(R) - \bar{r})^2)$. Taking the cumulative sum and dividing by the number of indexes of $r_i = 1104$ will give the variance of 0.004619958.

To calculate **semivariance**, the formula is

$$S(R) = \frac{\sum_{r_t < Average}^{n} (\bar{r} r_i)^2}{n}$$

I broke up the calculation into 2 steps. I first used conditional formatting in the column of r_i's to determine which values are $< \bar{r}$, and then with those values, I calculated $E(R) - r_t$ for t-values which meet this criteria. The semi-variance is 0.699413548.

To calculate **stdev**, I square root the variance to get $\sigma = 0.06797027$.

IBM continuously compounded	
	using 'n-1'
min	-0.303682414
max	0.302914465
median	0.010186212
mean	0.010610882
variance	0.004619958
semi-var	0.699413548
std dev	0.06797027
skewness	-0.180610707
kurtosis	2.180926495

Figure 1: Summary Statistics

To calculate **skewness**, I used the formula

$$skewness = \frac{\sum_{i=1}^{n} (r_i - \bar{r})^2/n}{s^3}$$

. I first calculated the numerator and summed up over all indexes, then divided by 1106. Then, I divided by σ^3 to get $skewness = -0.1806107$.

Calculate **kurtosis**:

$$kurtosis = \frac{\sum_{i=1}^{n} (r_i - \bar{r})^4/n}{s^4} - 3$$

- For both skewness and kurtosis, I used the standard deviation value with $(n-1)$ ('B10') due to the adjustment needed for degrees of freedom in using sample data.

Part B: Using 'Question 1.b)' tab:

I used 35 bins of size 0.017331. From the bins, the functions of NORMDIST() and FREQUENCY() allow me to calculate the empirical probability. The frequency of the bins is what determines the heights of the bars in the histogram. To find the critical return (r*) of the 1% percentile of the distribution, one just looks at the orange histogram bars, and read the associated cumulative empirical probability up to 1%.

The associated 1% percentile is between (-0.200429, -0.183), so I will interpolate. The associated 1% percentile can be calculated as:

$$|-0.200429 + 0.183| = 0.017429 \quad (1)$$
$$0.01 - 0.009058 = 0.000942 \quad (2)$$
$$0.011775 - 0.0009058 = 0.002717 \quad (3)$$
$$\frac{0.000942}{0.002717} = 0.346705926 \quad (4)$$
$$0.3467 * 0.017429 = 0.006040891 \quad (5)$$
$$0.006040891 + (-0.200429) = -0.194388109 \quad (6)$$

(1) is the width of the two bounds of 0.01 (bin-wise). (2) is the difference between the lower bound and our desired 1% value. (3) is the difference of the lower and upper bound of the cum emp probability interval. (4) is the interpolation percentage needed to determine the point value of 1%. (5) calculates the interpolated value within the bin interval. (6) is the final value in adding the interpolated value and the original lower bin bound.

I find the $r* = -0.194388109$. The potential 1-period-ahead losses of investing in 100 dollars would be -0.19438*100 = -$19.44. The percentile value tells us on average, the 1% loss that will be incurred in a portfolio of value p (in this case = 100 dollars).

Part C: Using 'Question 1.c)' tab:

The normal distribution is illustrated in blue. The NORMDIST() function was used with the values of $\bar{r}$ and σ^2 as found in (a). The CDF of this distribution is summed over all values, and we know the distribution is valid as it sums up to ~ 1.

$$|-0.148143 + 0.130714| = 0.017429 \quad (1)$$
$$0.01 - 0.009755 = 0.000245 \quad (2)$$
$$0.018799 - 0.0009755 = 0.0178235 \quad (3)$$
$$\frac{0.000245}{0.0178235} = 0.013745897 \quad (4)$$
$$0.013745897 * 0.017429 = 0.000239577 \quad (5)$$
$$0.000239577 + (-0.148143) = -0.147903423 \quad (6)$$

(1) is the width of the two bounds of 0.01 (bin-wise). (2) is the difference between the lower bound and our desired 1% value. (3) is the difference of the lower and upper bound of the cum normal distribution probability interval. (4) is the interpolation percentage needed to determine the point value of 1%. (5) calculates the interpolated value within the bin interval. (6) is the final value in adding the interpolated value and the original lower bin bound.

We find the $r* = -0.147903423$. The potential 1-period-ahead losses of investing in 100 dollars would be

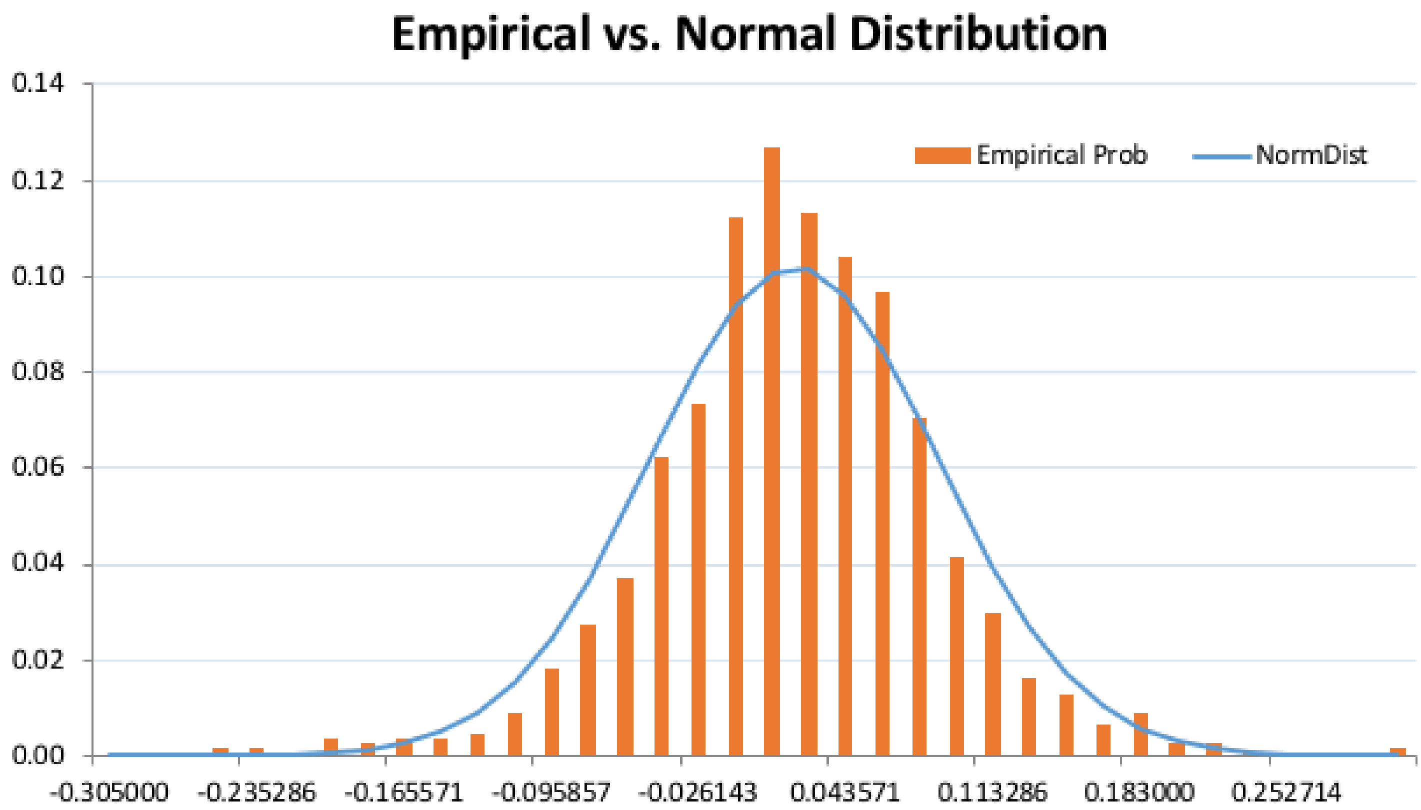

Figure 2: Normal Superimposed on Histogram

$(-0.147903423) \times 100 = -14.79$. Reasoning is as above. In checking the VaR at 1% using the NORMINV() function, I receive a *very* similar answer, of 14.75.

In comparison with my answer from (b), the estimate is much lower. This is due to the empirical probability being calculated based on an unknown distribution and the frequencies of the distribution only generated on this data sample. This distribution as a smoothed version of a histogram may not represent its density appropriately. Usually, the empirical distribution will not match the normal distribution exactly.

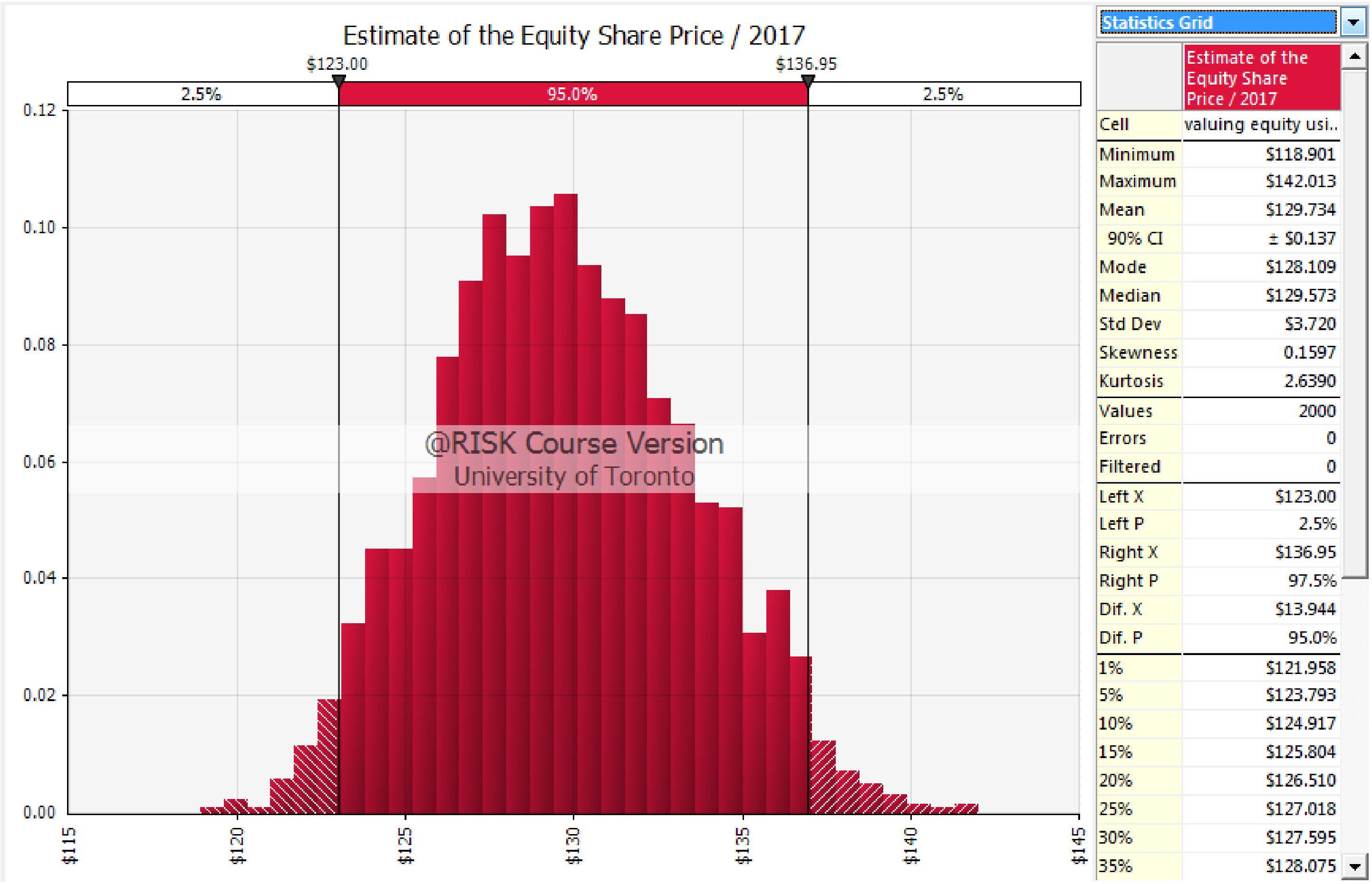

Figure 3: Estimate of Confidence Interval

Question 2

- A caveat to this question is that I would have assumed that because stock prices follow a lognormal distribution, when I define the distribution, the lognormal setting should be selected. However, I am not sure how to use the parameters μ and σ in the Monte Carlo simulation. Proceeding, I used the normal distribution to run the simulation.

Procedure

I use a weighted average of 50% from the equity valuation estimate and 50% from the 2-stage DDM. The estimate of the equity share price under this method is $131.42. I run a simulation of 2000x with the function of 0.50 weight in FCFF and 0.50 weight in the DDM model. The 95% confidence interval is (123.00, 136.95).

I chose to equally weight both models due to not enough information provided to weight either model more strongly. I chose to pair the FCFF model with the 2-stage DDM as the FCFF assumption is a firm with FCF's growing at a stable rate, and the DDM is under a static growth rate. Taking a weighted average of these two (with similar assumptions) would provide a more reasonable forecast.

To interpret the 95% confidence interval of (123.00, 136.95) means on average in a large sample, in 95% of the trials conducted on sampling the estimate of the equity share price, the mean of these trials will fall within this interval range.

Some sources of model uncertainty would be that:

It is unknown if there are any "expected" economic conditions that are upcoming. Structural breaks or regime switches could impact the stability of the markets, which would also endanger the stability of any stocks in the markets. But if these sources of uncertainty are predicted to be upcoming (i.e. one such example: Brexit), then one could try to take these confounding variables into account, and adjust accordingly for say- certain industries that would be impacted more heavily, so the adjustment in forecasting would be more downward-sloped for more recent periods, than those industries which would not be so much due to low sensitivity.

Also, not enough information on the companies is provided. I used my finance knowledge judgment in choosing the 2-stage DDM model in combination with the FCFF model, as a best tool of forecasting in quantifying risks and uncertainties. Only relying on the "most plausible" estimate or always relying on one model is not correct as uncertainty having no distribution, means one is more prepared if they have a well-defined risk distribution.