Comparing Microsoft and Apple stocks

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**Introduction**

For anyone who has been following technology or not, they will know about Microsoft and Apple. Microsoft and Apple are two of the oldest and biggest players in Technology. Both have been founded by two revolutionary leaders in Bill Gates and Steve Jobs. They are dream organizations for anyone who envisions a career in Tech. They are one of the top 6 companies in Tech. Both companies have stocks that have been consistently performing well in the Stock market and have been existence before the dot-com boom that happened in the 1990s. Microsoft went public in 1980 while Apple went public in 1986 and both have been continuing to dominate the technology stocks continuously. While both companies have been doing good, an investor would always wonder which one is better than the other. The main motivation behind choosing these big players is my personal interest in these two companies. As someone who is an avid technology news reader, these two companies have become synonymous with everyday life right from basic products we use to the services we use. Microsoft Office products like Word, Excel, PowerPoint, Access, Windows OS or Apple products like the iPhone, Mac and services like iCloud and IMessage, IOS have become our go-to products for personal and business uses. They are among the top choice of stocks for most technology stock followers. Thankfully, in this modern day and time, we do not have to rely on just investment brokers to help us make that decision. Back in the day, investment brokers would play a huge part in helping to buy a stock. Today, we have apps like Robinhood which also help with a stock investment. With Risk analysis and portfolio optimization packages available at our disposal today, it helps in evaluating the risk behind each stock. The investor can get more control this way and not just rely on a third party like an app or an actual human stockbroker.

**Research Question**

With these two company stocks in question, a new or an existing investor will always wonder which stock they should invest in first or should they invest in a combination of both Apple and Microsoft stocks. Having got into stock market investing, a new investor would wonder between two of the greatest technology stocks on which they should choose first. An existing investor who does not already know can use this analysis as well. Essentially, the research problem being tackled is if one stock is more valuable to buy than the other or is it more valuable to buy a combination of both Apple and Microsoft. By evaluating these stocks using individual Expected Shortfall and Value at Risk and the combined Expected Shortfall and Value at Risk, it would be a good way to tell if one stock is a better investment than the other or if a combination of the two stocks is the best way to go.

**Methodology**

**Data Gathering**

The data was obtained from Yahoo Finance. As a first step, the data was obtained for Apple and Microsoft separately using a ‘quantmod’ package in R. The ‘getSymbols’ method in this ‘quantmod’ package helps to retrieve the historical stock data. This historical data that is used in the analysis here, goes as back as the start of the market in the year 2000 (January 3rd) and goes until the end of September 2020. It contains 31,314 records and 6 columns for each Apple and Microsoft since both companies were existing during this timeframe. The data thus contains close to 20 years of stock related data for each of the two companies. This wide timeframe was chosen arbitrarily because it gives a good size of data to make a conclusive observation of the data. It contains the following columns: Stock opening price, High price of the day, low price of the day, Closing Price of the Day, Volume of Shares, Adjusted Price. Each row in the observation represents a new trading day in the stock market and so it represents the corresponding stock related information, i.e., Stock open, close, high, low, volume, adjusted price for that specific day.

**Data Preprocessing & Analysis**

Once the dataset was retrieved for Apple and Microsoft using the quantmod package, the “Date” was the index used for getting stock related info. So, the index was shifted to make Date as a column which can then be used in the risk analysis. Using Date as a character variable, it was used in timeseries format, for which the timeseries package was used and using the ‘returnseries’ function in the FRAPO package, the daily returns of each of the two stocks was calculated. The ‘Closing Price’ field of both the stocks were used to evaluate the returns. ‘Closing Price’ was used here as the evaluating field because it is only useful to see the closing price at the end of the stock trading day. The FRAPO package is the Financial Risk Modelling and Portfolio Optimization package which was used heavily here. A subset each for Apple and Microsoft was then created which contained only Date and return fields from the original data and the missing values were removed. Time attribute was created for each of the date field so that they can be used for the return later. Variables representing the mean expected returns of each of the two stocks were created and combined and stored in a vector. In addition, variables representing the variance of returns of each Apple and Microsoft were created with a view to capture volatility of each of the two stocks were created and combined and stored in a vector.

For the individual portfolios of Microsoft and Apple, the AIC diagnostics were used to see which model fits best. For Microsoft, asymmetric ghyp distribution and for Apple, asymmetric VG model were best fit based on low AIC values. They were then fit to the individual return variables according to the model chosen. Then the value at risk and expected shortfall were calculated for probabilities 0.01, 0.05 and 1 and results were reported.

For creating a personalized portfolio of weighted combination of the two stocks, a formula was then created to calculate the value at Risk and expected return for the combination of Apple and Microsoft. This formula took both returns and one of their weights as input parameters and made use of means of both stocks, variances, correlation and use that to calculate risk and expected return. A dataset was then created which contained a combination of Apple and Microsoft return and the missing values were omitted. Pairwise co-variance matrix was created. The dataset created previously which was used as a combination of Apple and Microsoft was then used to find weights of the Global Minimum Variance Portfolio. This helped to calculate suggested weights. Using the formula created earlier to calculate risk and expected return, the risk and expected return of the portfolio with GMVP weights were calculated. A variable that represents daily returns of the GMVP portfolio was created and converted to timeseries format. stepAIC.ghyp() function was used to see which distribution has closest fit to the actual distribution of the created variable’s returns. The created variable in the previous step which represents daily returns of the GMVP portfolio was then fit to the chosen model which is NIG Asymmetric in this case and then they were then fit to the portfolio variable according to the model chosen. Then the value at risk and expected shortfall were calculated for probabilities 0.01, 0.05 and 1 and results were reported.

**Strengths & Weaknesses of the Analysis**

One of the strong points of the analysis is the fact that the data being used contains a huge size of data of more than 30,000 data points. It contains almost 20 years of data which is a large timeframe. This large timeframe makes it a weaker model as well. The market conditions could have changed significantly in the last 5 years. Both have had different CEOs in the past decade so only considering that may have had made it stronger and probably given a different result.

**Results**

When the expected mean of the Apple returns and Microsoft returns was calculated, it was noted that Apple offers higher average return than Microsoft. Apple offers 0.09% average expected return and Microsoft offers 0.02% average expected return. Apple has higher variance of 7.09% and Microsoft has lower variance of 3.83%. So, while Apple is offering a higher expected return, it can be said that Apple is more volatile than Microsoft. Using Global Minimum Variance Portfolio, an expected return of 0.04 and variance of 1.86% was obtained for the combination of Apple and Microsoft stocks. It was Asymmetric NIG model is observed to be the best fit distribution using stepAIC.ghyp() function based on the low AIC value than other models.

For the Microsoft portfolio, there is a 1% chance that losses tomorrow will exceed 5.7 (Value at Risk) and when that happens you as the investor will stand to lose 7.99 (Expected Shortfall) on average, a 5% chance that losses tomorrow will exceed 2.88 (Value at Risk) and when that happens you as the investor will stand to lose 4.68 (Expected Shortfall) on average, a 10% chance that losses tomorrow will exceed 1.92 (Value at Risk) and when that happens you as the investor will stand to lose 3.51 (Expected Shortfall) on average.

For the Apple portfolio, Asymmetric VG model is observed to be the best fit distribution using stepAIC.ghyp() function based on the low AIC value than other models. There is a 1% chance that losses tomorrow will exceed 6.68 (Value at Risk) and when that happens you as the investor will stand to lose 8.43 (Expected Shortfall) on average, a 5% chance that losses tomorrow will exceed 3.88 (Value at Risk) and when that happens you as the investor will stand to lose 5.62 (Expected Shortfall) on average, a 10% chance that losses tomorrow will exceed 2.68 (Value at Risk) and when that happens you as the investor will stand to lose 4.41 (Expected Shortfall) on average.

Using weighted combination of Apple and Microsoft, an expected return of 0.04 and variance of 1.86% was obtained for the combination of Apple and Microsoft stocks. Asymmetric NIG model is observed to be the best fit distribution using stepAIC.ghyp() function based on the low AIC value than other models. For the Weighted combination of Apple and Microsoft, there is a 1% chance that losses tomorrow will exceed 5.52 (Value at Risk) and when that happens you as the investor will stand to lose 7.48 (Expected Shortfall) on average, a 5% chance that losses tomorrow will exceed 2.86 (Value at Risk) and when that happens you as the investor will stand to lose 4.54 (Expected Shortfall) on average, a 10% chance that losses tomorrow will exceed 1.9 (Value at Risk) and when that happens you as the investor will stand to lose 3.43 (Expected Shortfall) on average.

**Conclusion**

Since Apple offers approximately 0.09% average return and Microsoft offers around 0.02%, it can be said the average return for Apple is nearly 4.5 times that of the average return for Microsoft. When the variance was being calculated, it was observed that Apple is more volatile than Microsoft. With a variance of 7.09%, Apple is riskier than Microsoft which has a variance of 3.83%. Using Value at Risk (VaR) and Expected Shortfall (ES) values above, we are able to further validate that Apple stock purchase will have higher losses than Microsoft stocks since Apple has Value at Risk and Expected Shortfall values higher than Microsoft. However, the combination of these two will be a better buy if one is interested in both since the losses and expected shortfall can be mitigated than both Microsoft and Apple individually. So, if you as an investor want to decide between Microsoft and Apple, go for Microsoft else if you want higher returns than go for Apple. I am not a stock market expert so please consider this as a suggestion**.** If an investor is a safety-first approach taking person, they may go for Microsoft if they want to only buy one of them else go for Apple for higher returns. While Apple is a more profitable stock to buy it is a riskier buy than Microsoft. A weighted combination is always a better investment as those losses and expected shortfalls can be reduced.

# References

Yahoo Finance. (2020). quantmod package. Yahoo Finance.

Buryi, P. (2020). *Assignment 2.*

Appendix

**R Code**

**```{r}**

**getwd()**

**dir="C:/Users/mukun/OneDrive/harrisburg/515 risk assessment/RStudio"**

**setwd(dir)**

**library(QRM)**

**library(fGarch)**

**library(FRAPO)**

**library(timeSeries)**

**library(quantmod)**

**aapl <- getSymbols("aapl", src = "yahoo", from = "2000-01-01", to = "2020-09-30", auto.assign = FALSE)**

**head(aapl)**

**#aapl<-as.data.frame(aapl)**

**msft <- getSymbols("msft", src = "yahoo", from = "2000-01-01", to = "2020-09-30", auto.assign = FALSE)**

**#msft<-as.data.frame(msft)**

**head(msft)**

**length(aapl)**

**length(msft)**

**library(data.table)**

**aapl=as.data.frame(aapl)**

**setDT(aapl, keep.rownames = TRUE)[]**

**colnames(aapl)**

**names(aapl)[names(aapl)=="rn"]<-"Date"**

**head(aapl)**

**msft=as.data.frame(msft)**

**setDT(msft, keep.rownames = TRUE)[]**

**colnames(msft)**

**names(msft)[names(msft)=="rn"]<-"Date"**

**head(msft)**

**aapl$Date=as.Date(aapl$Date, origin = "1900-01-01")**

**head(aapl)**

**msft$Date=as.Date(msft$Date, origin = "1900-01-01")**

**head(msft)**

**aapl<-aapl**

**msft<-msft**

**head(msft)**

**Date<-aapl$Date**

**library(timeSeries)**

**aaplPrice<-aapl$AAPL.Close**

**aaplPriceTS<-timeSeries(aaplPrice, charvec = Date)**

**aapl$aaplRet<-returnseries(aaplPriceTS)**

**msftPrice<-msft$MSFT.Close**

**msftPriceTS<-timeSeries(msftPrice, charvec = Date)**

**msft$msftRet<-returnseries(msftPriceTS)**

**aaplsubset=subset(aapl,select=c(Date,aaplRet))**

**msftsubset=subset(msft,select=c(Date,msftRet))**

**aaplsubset=na.omit(aaplsubset)**

**msftsubset=na.omit(msftsubset)**

**head(aaplsubset)**

**aaplret= aapl$aaplRet[complete.cases(aapl$aaplRet)]**

**msftret=msft$msftRet[complete.cases(msft$msftRet)]**

**head(aaplret)**

**attr(aaplret, 'time')<-date**

**attr(msftret, 'time')<-date**

**expaaplret<-mean(aaplret,na.rm=TRUE)**

**expmsftret<-mean(msftret,na.rm=TRUE)**

**c(expaaplret,expmsftret)**

**varaapl<-var(aaplret,na.rm = TRUE)**

**varmsft<-var(msftret,na.rm = TRUE)**

**c(varaapl,varmsft)**

**portriskret<-function(x,y,wx){**

**varx<-var(x, na.rm = TRUE)**

**vary<-var(y, na.rm = TRUE)**

**meanx<-mean(x, na.rm = TRUE)**

**meany<-mean(y, na.rm = TRUE)**

**corxy<-cor(x,y, use="pairwise.complete.obs")**

**risk<-wx^2\*varx+(1-wx)^2\*vary+2\*sqrt(varx)\*sqrt(vary)\*wx\*(1-wx)\*corxy**

**ERp<-wx\*meanx+(1-wx)\*meany**

**c(ERp, sqrt(risk))**

**}**

**#one<-portriskret(aaplret,msftret, 0.6,0.35)**

**#one[1]/one[2]**

**# To check for any individual coin, we can divide expected rate by variable rate**

**c(expaaplret,expmsftret)/c(varaapl,varmsft)**

**portriskret(aaplret,msftret, 0.6)**

**aaplrets=c(expaaplret,varaapl)**

**msftrets=c(expaaplret,varmsft)**

**coinsrets<-cbind(aaplret,msftret)**

**coinsrets<-na.omit(coinsrets)**

**head(coinsrets)**

**coinscov=cov(coinsrets, use="pairwise.complete.obs")**

**ERC<-PGMV(coinsrets)**

**str(ERC)**

**w<-Weights(ERC)**

**waapl<-as.numeric(w[1])/100**

**wmsft<-as.numeric(w[2])/100**

**waapl**

**wmsft**

**gmvpretrisk<-portriskret(aaplret,msftret,waapl)**

**gmvpretrisk**

**myport<-waapl\*aaplret+wmsft\*msftret**

**library(ghyp)**

**library(timeSeries)**

**library(fBasics)**

**myportts<-timeSeries(myport)**

**str(myportts)**

**head(myportts)**

**## Diagnostics to check which model works best**

**AIC <- stepAIC.ghyp(myportts, control = list(maxit = 1000))**

**AIC$fit.table**

**## Diagnostics to check which model works best**

**AICm1 <- stepAIC.ghyp(msftPriceTS, control = list(maxit = 1000))**

**AICm1$fit.table**

**## Diagnostics to check which model works best**

**AICa1 <- stepAIC.ghyp(aaplPriceTS, control = list(maxit = 1000))**

**AICa1$fit.table**

**# Since we chose ghyp model, we will fit that to myport**

**NIGfit<- fit.NIGuv(myport, symmetric = FALSE, control = list(maxit = 1000), na.rm = TRUE)**

**VGfit\_aapl<- fit.VGuv(aaplret, symmetric = FALSE, control = list(maxit = 1000), na.rm = TRUE)**

**fit\_msft<- fit.ghypuv(msftret, symmetric = FALSE, control = list(maxit = 1000), na.rm = TRUE)**

**## Probabilities**

**p <- c(0.01, 0.05,0.1)**

**p**

**portvar<- qghyp(p, NIGfit)**

**portvar**

**aaplvar<- qghyp(p, VGfit\_aapl)**

**aaplvar**

**msftvar<- qghyp(p, ghypfit\_msft)**

**msftvar**

**portes<-ESghyp(p,NIGfit)**

**portes\_aapl<-ESghyp(p,VGfit\_aapl)**

**portes\_msft<-ESghyp(p,ghypfit\_msft)**

**portes**

**portvar**

**portes\_msft**

**msftvar**

**portes\_aapl**

**aaplvar**

**```**