ORIE 4630 Final Project: Communication Services

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2024-12-14

```r
# between the most popular ETFs tracking the communications sector, VOX was the only one that started b
getSymbols("VOX", from = "2017-01-01", to = "2019-12-31")
```

```
## [1] "VOX"
```

```r
# these are the top 3 largest holdings in VOX, and also the largest companies in the sector
getSymbols("GOOG", from = "2017-01-01", to = "2019-12-31")
```

```
## [1] "GOOG"
```

```r
getSymbols("META", from = "2017-01-01", to = "2019-12-31")
```

```
## [1] "META"
```

```r
getSymbols("NFLX", from = "2017-01-01", to = "2019-12-31")
```

```
## [1] "NFLX"
```

```r
# using the 3-month treasury bill as the risk free rate
DTB3 <- read.csv(paste0("./DTB3.csv"), header = TRUE)
DTB3 <- DTB3[!is.na(DTB3$DTB3),]
```

Question 1

Calculate daily returns for your industry for 2017-2019. Download two types of data for this - the industry level series on Yahoo Finance, and the top 3 or 4 companies in the sector. Justify the ticker choice you made to represent the industries (e.g., the most famous ones, largest ones, ones you are particularly curious about, etc.). Plot the cumulative performance of the industry and the individual assets.

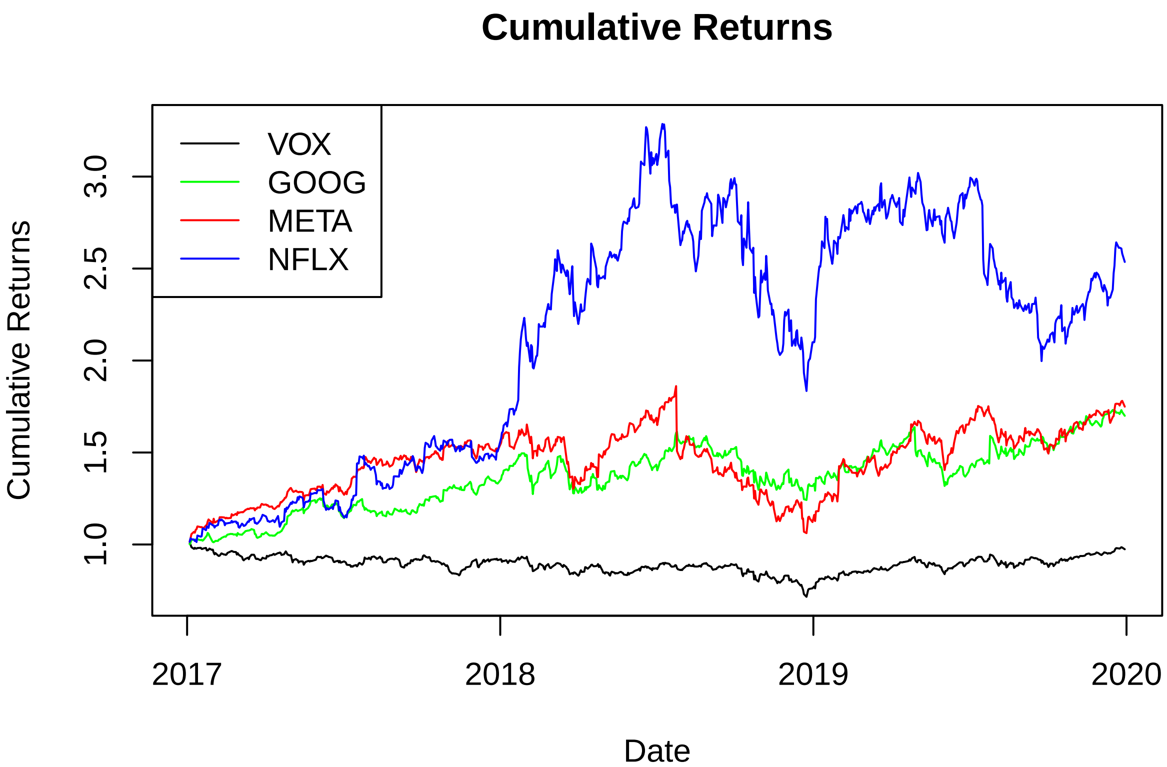
```r
VOX_returns <- dailyReturn(VOX$VOX.Adjusted, type = "arithmetic")[-1]
GOOG_returns <- dailyReturn(GOOG$GOOG.Adjusted, type = "arithmetic")[-1]
META_returns <- dailyReturn(META$META.Adjusted, type = "arithmetic")[-1]
NFLX_returns <- dailyReturn(NFLX$NFLX.Adjusted, type = "arithmetic")[-1]

returns <- merge(VOX_returns, GOOG_returns, META_returns, NFLX_returns)
colnames(returns) <- c("VOX", "GOOG", "META", "NFLX")
head(returns)
```

```
##                     VOX          GOOG         META          NFLX
## 2017-01-04  0.006865129  0.0009668652  0.015659715  0.0150600504
## 2017-01-05 -0.007298551  0.0090481495  0.016682145  0.0185456598
## 2017-01-06 -0.013833603  0.0152766825  0.022706542 -0.0056140676
## 2017-01-09 -0.009711797  0.0006203140  0.012073574 -0.0009156204
## 2017-01-10  0.005943535 -0.0023060122 -0.004403511 -0.0080946742
## 2017-01-11 -0.003840341  0.0038768784  0.013992721  0.0046962862
```

```r
VOX_cum <- cumprod(1 + VOX_returns)
GOOG_cum <- cumprod(1 + GOOG_returns)
META_cum <- cumprod(1 + META_returns)
NFLX_cum <- cumprod(1 + NFLX_returns)

plot(index(VOX_cum), VOX_cum, type = "l", col = "black", lwd = 1,
     xlab = "Date", ylab = "Cumulative Returns", main = "Cumulative Returns",
     ylim = range(c(VOX_cum, GOOG_cum, META_cum, NFLX_cum), na.rm = TRUE))
lines(index(GOOG_cum), GOOG_cum, col = "green", lwd = 1)
lines(index(META_cum), META_cum, col = "red", lwd = 1)
lines(index(NFLX_cum), NFLX_cum, col = "blue", lwd = 1)
legend("topleft", legend = c("VOX", "GOOG", "META", "NFLX"),
       col = c("black", "green", "red", "blue"), lty = 1, lwd = 1)
```



Question 2

Report summary statistics like mean and sd for daily returns by year and industry i.e., in two Nx2 table with periods along the columns and assets along the rows. N denotes the number of assets (i.e., number of individual companies and the overall series). One table is for reporting mean, the other for sd.

```r
returns_by_year <- split(returns, format(index(returns), "%Y"))

mean_table <- sapply(returns_by_year, function(year_data) colMeans(year_data, na.rm = TRUE))
sd_table <- sapply(returns_by_year, function(year_data) apply(year_data, 2, sd, na.rm = TRUE))

cat("Mean of Daily Returns, by Year (2017-2019):\n")
```

```
## Mean of Daily Returns, by Year (2017-2019):
```

```r
print(mean_table)
```

```
##               2017          2018         2019
## VOX  -0.0003190948 -0.0006583970 0.0010236329
## GOOG  0.0011913282  0.0001158744 0.0011306652
## META  0.0017069666 -0.0008865413 0.0019244563
## NFLX  0.0017891463  0.0017513091 0.0009908407
```

```r
cat("\nStandard Deviation of Daily Returns, by Year (2017-2019):\n")
```

```
##
## Standard Deviation of Daily Returns, by Year (2017-2019):
```

```r
print(sd_table)
```

```
##             2017       2018        2019
## VOX  0.008447894 0.01197733 0.009482158
## GOOG 0.009695776 0.01772353 0.015237989
## META 0.010700618 0.02397114 0.017595568
## NFLX 0.017563650 0.02924640 0.021852880
```

Question 3

Use techniques we learnt in portfolio optimization to create an optimal portfolio of the individual companies in your industry. Comment on the riskiness of the assets, the overall series and your constructed portfolio in the Markowitz portfolio optimization world (meaning using standard deviations and Sharpe ratios).

I am using the 3-month treasury bills as the risk-free rate. https://fred.stlouisfed.org/series/DTB3

SOFR was only caluclated since 04-2018.

```r
mu.vec <- colMeans(returns, na.rm = TRUE)
sd.vec <- apply(returns, 2, sd, na.rm = TRUE)
trading_days <- nrow(returns)
rf_annual <- mean(DTB3$DTB3[DTB3$observation >= as.Date("2017-01-01") & DTB3$observation <= as.Date("20
rf <- rf_annual / trading_days / 100
Sigma = cov(returns[,-1])
```

Calculate the tangency portfolio

```r
num = solve(Sigma)%*%(mu.vec[-1]-rf)
den = as.numeric(t(rep(1,3))%*%solve(Sigma)%*%(mu.vec[-1]-rf))
tan.vec = num/den
mu_tan = as.numeric(crossprod(tan.vec, mu.vec[-1]))
sd_tan = sqrt(as.numeric(t(tan.vec)%*%Sigma%*%tan.vec))

tanpf = rbind(mu_tan, sd_tan, tan.vec)
rownames(tanpf) = c("mean", "sd", "GOOG", "META", "NFLX")
colnames(tanpf) = c("tangency pf")

print(round(tanpf,3))
```

```
##      tangency pf
## mean       0.001
## sd         0.017
## GOOG       0.315
## META       0.211
## NFLX       0.474
```

```r
voxpf = rbind(mu.vec[1], sd.vec[1])
rownames(voxpf) = c("mean", "sd")
print(voxpf)
```

```
##               VOX
## mean 1.582515e-05
## sd   1.009340e-02
```

Calculate the Sharpe Ratios

```r
top.mat = cbind(2*Sigma, rep(1, 3))
bot.vec = c(rep(1, 3), 0)
Am.mat = rbind(top.mat, bot.vec)
b.vec = c(rep(0, 3), 1)
zm.mat = solve(Am.mat)%*%b.vec
wmin.vec = zm.mat[1:3,1]
mu_min = as.numeric(crossprod(wmin.vec, mu.vec[-1]))
sd_min = sqrt(as.numeric(t(wmin.vec)%*%Sigma%*%wmin.vec))

SR_VOX = (mu.vec[1]-rf)/sd.vec[1]
SR_GOOG = (mu.vec[2]-rf)/sd.vec[2]
SR_META = (mu.vec[3]-rf)/sd.vec[3]
SR_NFLX = (mu.vec[4]-rf)/sd.vec[4]
SR_min = (mu_min-rf)/sd_min
SR_tan = (tanpf[1] - rf)/tanpf[2]
sr = rbind(SR_VOX, SR_GOOG,SR_META, SR_NFLX, SR_min, SR_tan)
rownames(sr) = c("SR_VOX", "SR_GOOG","SR_META", "SR_NFLX", "SR min var", "SR tangency")
colnames(sr) = c("Sharpe Ratios")
round(sr*100,3)
```

```
##             Sharpe Ratios
## SR_VOX             -0.060
## SR_GOOG             5.411
## SR_META             4.881
## SR_NFLX             6.368
## SR min var          5.867
## SR tangency         6.870
```

Analysis Looking at the individuals stocks, we see that Netflix has the highest Sharpe Ratio of 6.368, and thus has the most attractive risk-adjusted return. However, Google and Meta are not far behind at 5.411 and 4.881. Thus, the tangential portfolio puts the highest weight on NFLX, but still a significant proportion in the others. All of them are above 3 and thus very good stocks to invest in. The Sharpe Ratio of the tangency portfolio is higher than each individual stock, at 6.870. This is much higher than the Sharpe Ratio of VOX, which is at -0.060.

The tangency porfolio performs quite well, averaging 0.1% growth per trading day but with a high standard deviation of 1.7%. Compared to the VOX, which averages a much lower 0.002% growth per trading day and with a smaller standard deviation of 1.0%. VOX is a safer investment for sure, but gives much worse expected returns, even when adjusted for risk.

TODO: Make graph, check to make sure my calculations (0.1%, 0.002%, etc. are correct and per day)