# Econometrics - Collaborative Review Task 1

## 1. CAPM Equation

$$r_i = r_f + \beta_i(r_m - r_f)$$

where,

$\beta_i$ = beta between stock and market

$r_i$ = Expected return of the stock

$r_f$ = Risk free return

$r_m$ = Market return

## 2. CAPM model in explaining the return of stock.

CAPM model is one of the widely used model in calculating the expected return of a stock based on its level of risk. The risk involved in a stock is measured as beta ($\beta$), which is a comparison of historical return of the stock with that of a market portfolio. For ex., S&P500.

From the above equation, the term $r_f$ is the risk free return, that an investor can get. This is assumed to be an investment in government bond, that has very minimal level of risk.

$(r_m - r_f)$ is the premium that an investor gains for the level of risk he holds ($\beta$ being the measure of risk of the asset)

For example, let's consider company A has $\beta = 0$. The above equation becomes $r_i = r_f$. This means, the company A has no relevant risk and a return of the Risk-free rate (the return of a government bill) can be expected on investment.

Company B has a $\beta$ of 1. The equation becomes $r_i = r_m$. This just means, the expected return of company B is the same as investing in the considered market portfolio.

## 3. Adjusted closing price of QUALCOMM Incorporated (QCOM) between 01-Jan-2021 and 31-Dec-2022

The adjusted closing price can be fetched by using tq_get(...) from tidyquant package.

```
#import required libraries
library(tidyverse)
library(tidyquant)
library(data.table)
library(reshape2)
library(glue)
options(pillar.sigfig = 5)
```

```r
#get adjusted close price  of QUALCOMM stock for 1 year using tq_get
qcom = tq_get("QCOM",
          from = "2021-01-01",
          to = "2022-01-01")[c('date','adjusted')]
#Print first 6 rows
head(qcom)
```

```
## # A tibble: 6 x 2
##   date       adjusted
##   <date>        <dbl>
## 1 2021-01-04   145.21
## 2 2021-01-05   149.05
## 3 2021-01-06   147.84
## 4 2021-01-07   152.25
## 5 2021-01-08   153.17
## 6 2021-01-11   152.65
```

```r
#Print last 6 rows
tail(qcom)
```

```
## # A tibble: 6 x 2
##   date       adjusted
##   <date>        <dbl>
## 1 2021-12-23   181.98
## 2 2021-12-27   185.56
## 3 2021-12-28   184.05
## 4 2021-12-29   185.43
## 5 2021-12-30   181.97
## 6 2021-12-31   182.11
```

```r
#Print the dimension of data
dim(qcom)
```

```
## [1] 252   2
```

The table has 252 entries, which suggests the adjusted closing price of QUALCOMM for 1 year is fetched.

Let's plot the data to further verify.

```r
#plot the time series of the closing price
ggplot(qcom, aes(x=date, y=adjusted)) +
      geom_line(color = "darkblue", size = 0.8) +
      xlab("Days [months]") + ylab("Adjusted Closing Price [$]") +
      ggtitle("Time series plot of QUALCOMM stock price from 01-Jan-2021 to 31-Dec-2021")
```


# 4. Computing the daily and annual return of the stock

Simple daily return of a stock can be computed using:

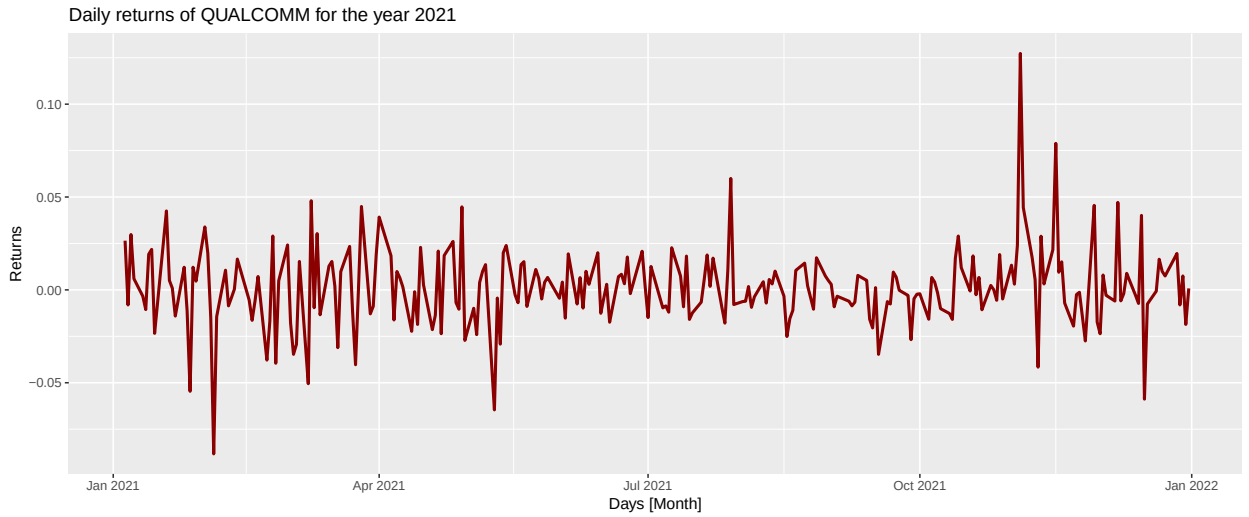
$$\frac{P_1}{P_0} - 1$$

```
# Calculating QUALCOMM daily return and adding it to a new column
qcom$daily.returns = round((qcom$adjusted / shift(qcom$adjusted,1) - 1),4)
head(qcom)
```

```
## # A tibble: 6 x 3
##   date       adjusted daily.returns
##   <date>        <dbl>         <dbl>
## 1 2021-01-04   145.21       NA
## 2 2021-01-05   149.05        0.0265
## 3 2021-01-06   147.84       -0.0081
## 4 2021-01-07   152.25        0.0298
## 5 2021-01-08   153.17        0.006
## 6 2021-01-11   152.65       -0.0034
```

Now, let's plot the daily returns.

```
#Plotting daily returns of QUALCOMM stock
ggplot(qcom, aes(x = date, y = daily.returns)) +
  geom_line(color = "darkred", size=1) +
  xlab("Days [Month]") +
  ylab("Returns") +
  ggtitle("Daily returns of QUALCOMM for the year 2021")
```




Annual return can be computed as the product of the mean of daily returns and the number of trading days.

```
#Computing annual return
avg.annual.qcom.return = round(mean(qcom$daily.returns,
                                    na.rm = TRUE)
                               * nrow(qcom),4)

glue("Average annual return of QUALCOMM stock is {avg.annual.qcom.return * 100}%")
```

```
## Average annual return of QUALCOMM stock is 28.56%
```

## 5. Stock's beta

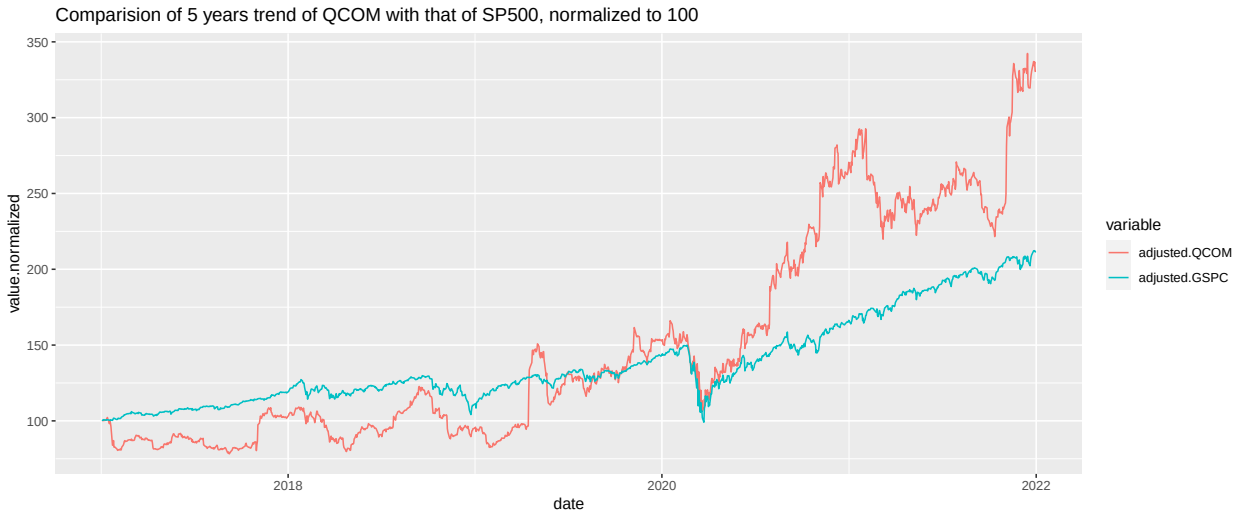
To find the beta, we will use **five years data** of QUALCOMM and approximate the development with S&P500

```
#Fetch 5 year stock price of QUALCOMM
qcom_5 = tq_get("QCOM",
                from = "2017-01-01",
                to = "2022-01-01")[c('date','adjusted')]

#Fetch 5 year stock price of SP500
baseline_5 = tq_get("^GSPC",
                 from = "2017-01-01",
                 to = "2022-01-01")[c('date','adjusted')]

#Join both data together by the date
data = merge(qcom_5, baseline_5, by = "date",
             suffixes = c(".QCOM",".GSPC"))

#Plotting the daily price of QUALCOMM and SP500, normalized to 100
data.long = melt(data, id.vars="date") %>%
            group_by(variable) %>%
            mutate(value.normalized = value / value[1] * 100)
ggplot(data.long,
       aes(x = date, y = value.normalized, col = variable)) +
  geom_line() +
  ggtitle("Comparision of 5 years trend of QCOM with that of SP500, normalized to 100")
```




```
#Computing QUALCOMM returns and adding it to a new column
data$QCOM.returns = round((data$adjusted.QCOM / shift(data$adjusted.QCOM,1) - 1),4)

#Computing S&P500 returns and adding it to a new column
data$GSPC.returns = round((data$adjusted.GSPC / shift(data$adjusted.GSPC,1) - 1),4)

head(data)
```

```
##         date adjusted.QCOM adjusted.GSPC QCOM.returns GSPC.returns
## 1 2017-01-03      55.05872       2257.83           NA           NA
## 2 2017-01-04      55.11765       2270.75       0.0011       0.0057
## 3 2017-01-05      55.18499       2269.00       0.0012      -0.0008
## 4 2017-01-06      55.16816       2276.98      -0.0003       0.0035
## 5 2017-01-09      55.26919       2268.90       0.0018      -0.0035
## 6 2017-01-10      55.25235       2268.90      -0.0003       0.0000
```

```
tail(data)
```

```
##            date adjusted.QCOM adjusted.GSPC QCOM.returns GSPC.returns
## 1254 2021-12-23      181.9809       4725.79       0.0075       0.0062
## 1255 2021-12-27      185.5560       4791.19       0.0196       0.0138
## 1256 2021-12-28      184.0522       4786.35      -0.0081      -0.0010
## 1257 2021-12-29      185.4265       4793.06       0.0075       0.0014
## 1258 2021-12-30      181.9709       4778.73      -0.0186      -0.0030
## 1259 2021-12-31      182.1103       4766.18       0.0008      -0.0026
```

Beta of the stock can be calculated by using

$$\beta_n = \frac{\sigma_{n,m}}{\sigma_m}$$

where,

$\beta_n$ = beta of QUALCOMM

$\sigma_{n,m}$ = Covariance between QUALCOMM and SP500

$\sigma_m$ = variance of SP500

```r
#Covariance between QUALCOMM returns and SP500 returns
cov.withmarket = var(data$QCOM.returns, data$GSPC.returns, na.rm = TRUE)
cov.withmarket
```

```
## [1] 0.0001768957
```

```r
#Variance of SP500 returns
var.market = var(data$GSPC.returns, na.rm = TRUE)
var.market
```

```
## [1] 0.0001468614
```

```r
#Computing beta of QUALCOMM stock
beta.qcom = cov.withmarket/var.market
beta.qcom
```

```
## [1] 1.204508
```

Beta calculated is closely equal to the one from yahoo finance: https://finance.yahoo.com/quote/QCOM

## 6. One year adjusted closing price of SP500

```r
#get adjusted close price of SP500 for 1 year from yahoo finance with tq_get
sp500 = tq_get("^GSPC",
          from = "2021-01-01",
          to = "2022-01-01")[c('date','adjusted')]
#Print first 6 rows
head(sp500)
```

```
## # A tibble: 6 x 2
##   date       adjusted
##   <date>        <dbl>
## 1 2021-01-04   3700.6
## 2 2021-01-05   3726.9
## 3 2021-01-06   3748.1
## 4 2021-01-07   3803.8
## 5 2021-01-08   3824.7
## 6 2021-01-11   3799.6
```

```r
#Print last 6 rows
tail(sp500)
```

```
## # A tibble: 6 x 2
##   date       adjusted
##   <date>        <dbl>
## 1 2021-12-23   4725.8
## 2 2021-12-27   4791.2
## 3 2021-12-28   4786.4
## 4 2021-12-29   4793.1
## 5 2021-12-30   4778.7
## 6 2021-12-31   4766.2
```

```r
#Print the dimension of the data
dim(sp500)
```

```
## [1] 252   2
```

## 7. Return of the benchmark

Same procedure as that of QUALCOMM stock can be used to compute the returns of the benchmark.

```
# Calculating the index's daily return and adding it to a new column
sp500$daily.returns = round((sp500$adjusted / shift(sp500$adjusted,1) - 1),4)
head(sp500)
```

```
## # A tibble: 6 x 3
##   date       adjusted daily.returns
##   <date>        <dbl>         <dbl>
## 1 2021-01-04   3700.6       NA
## 2 2021-01-05   3726.9        0.0071
## 3 2021-01-06   3748.1        0.0057
## 4 2021-01-07   3803.8        0.0148
## 5 2021-01-08   3824.7        0.0055
## 6 2021-01-11   3799.6       -0.0066
```

```
#Computing annual return
avg.annual.market.return = round(mean(sp500$daily.returns,
                                      na.rm = TRUE)
                                 * nrow(sp500),4)


glue("Average annual return of SP500 is {avg.annual.market.return * 100}%")
```

```
## Average annual return of SP500 is 26.27%
```

## 8. CAPM of QUALCOMM stock

Let's consider 3-months treasury to be the risk free return. The yield of 3-months treasury bill is 0.37% https://www.bloomberg.com/markets/rates-bonds/government-bonds/us

$$r_i = r_f + \beta_i(r_m - r_f)$$

```
riskfree.return = 0.0037

#Computing CAPM
expected.return = round(riskfree.return +
                        beta.qcom *
                        (avg.annual.market.return -
                        riskfree.return), 4)
glue("Expected return using CAPM model is {expected.return * 100}%")
```

```
## Expected return using CAPM model is 31.57%
```