Econ 21410 - Problem Set VII

Asset Pricing^{*}

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This homework should be done in LaTeX The homework will be graded on correctness, but will also heavily weight clarity and professionalism. Its better to not do some of the harder parts than to turn in an incomprehensible document. Your R script as well as a log-file should be submitted. Alternatively, use knitr to print your code inline in your latex document.

SUBMISSION: The homework must be emailed to Oliver and myself by 2p.m. Monday, May 19th. The email must include a pdf with the filename lastname_pset7.pdf and R code called lastname_pset7_code.R where "lastname" should be replaced with your last name. The subject of your email should be [ECON 21410: pset5 submission]

If you are struggling, please use the github page to ask for help!* Remember that asking and answering questions on our github page, coming to office hours to ask questions, and contributing to the class wiki are all worth participation credit, which is 10% of your grade in this class.

Getting Started

1. My lecture in class was based on the first lecture of Columbia University's Financial Engineering and Risk Management Part II Coursera course. Their site may be helpful if you need a reference.

2. Go to datacamp.com and complete their Quandl tutorial

3. Go to quandl.com. Make an account. In your account settings find your 'API Authentication Token'.

4. At the top of your R code you will need to include your Quandl Authentication Token:
   ```
   Quandl.auth("Insert your Authentication Token here")
   ```

5. Download the S&P500 index between the dates of 01-01-2011 to 05-12-2014. The S&P500 is a capitalization weighted index of the 500 largest publically listed firms in the United States. Here is it's quandl code name:
   ```
   SP500 <- "YAHOO/INDEX_GSPC"
   ```

^{*}Please email johneric@uchicago.edu and obrowne@uchicago.edu if you have questions.

6. Download the daily stock prices of the 5 largest publicly listed companies between the dates of 01-01-2011 to 05-12-2014. Here are their quandl code names:

```
largest5 <- c("GOOG/NASDAQ_AAPL", "GOOG/NYSE_XOM",
    "GOOG/NASDAQ_GOOG", "GOOG/NYSE_BRK_B", "GOOG/NYSE_WMT")
```

```
# Section 0: Loading Data =============================

start.date <- "2011-01-01"
end.date <- "2014-05-12"
time.diff <- as.Date(end.date) - as.Date(start.date)
dates <- as.Date(start.date):as.Date(end.date)

largest5 <- c("GOOG/NASDAQ_AAPL", "GOOG/NYSE_XOM",
    "GOOG/NASDAQ_GOOG", "GOOG/NYSE_BRK_B", "GOOG/NYSE_WMT")
SP500 <- Quandl("YAHOO/INDEX_GSPC", type = "raw", start.date,
    end.date)
SP500.rdiff <- Quandl("YAHOO/INDEX_GSPC", type = "raw",
    start.date, end.date, transform = "rdiff")

n <- length(largest5)

all.ts <- data.frame(matrix(ncol = n + 2, nrow = dim(SP500[1])))
all.ts.diff <- data.frame(matrix(ncol = n + 2, nrow = dim(SP500.rdiff[1])))

all.ts[, 1] <- SP500[, "Date"]
all.ts[, 2] <- SP500[, "Open"]/tail(SP500$Open, n = 1)
all.ts.diff[, 1:2] <- SP500.rdiff[, 1:2]

colnames(all.ts) <- c("Date", "S&P500", largest5)
colnames(all.ts.diff) <- c("Date", "S&P500", largest5)

for (i in 1:5) {
    time.series <- Quandl(largest5[i], type = "raw",
        start.date, end.date)
    time.series.diff <- Quandl(largest5[i], type = "raw",
        start.date, end.date, transform = "rdiff")
    all.ts[, i + 2] <- time.series$Close/tail(time.series$Close,
        n = 1)
    all.ts.diff[, i + 2] <- time.series.diff$Close
}

# =========================
```

Examining stock data

1. On a single figure, plot a time series of the prices of these 5 stocks and the S&P500 index. Normalize prices so all series begin with price of 1.
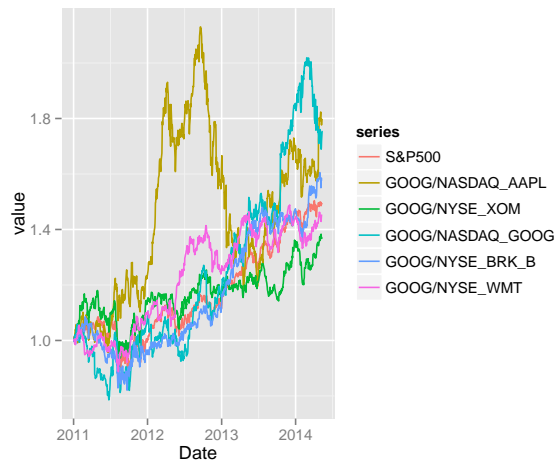
```
# Section 1: Plotting Stock Returns
# ==========================

all.ts.melt <- melt(all.ts, id = "Date", variable_name = "series")
ggplot(all.ts.melt, aes(Date, value)) + geom_line(aes(colour = series))
ggsave(file = "prices.pdf")


# ==========================
```

Figure 1: Stock prices

2. Caculate daily rates of return from all of your stock prices.

3. Why might one expect the distribution of returns on the S&P500 index to be normal?
   Perform a statistical test to check if this is so.

```
# Section 2: Normality of Returns
# ==========================

shapiro.test(SP500.rdiff$Open)
qqnorm(SP500.rdiff$Open)
qqline(SP500.rdiff$Open)
qplot(sample = SP500.rdiff$Open, stat = "qq")


# ==========================
```

4. Fit the best ARMA model of order no higher than (3,3) to the returns data for each of
   the 5 largest firms on the FTSE. Conduct a likelihood ratio test for the hypothesis that
   stock prices follow a random walk. Produce a table with your results. Are the results you
   find consistent with the efficent market hypothesis?

```
# Section 3: Fitting ARMA ==========================

loglikARMA <- rep(0, 5)
loglikRW <- rep(0, 5)
likRatioStat <- rep(0, 5)
pvalue <- rep(0, 5)
for (i in 1:5) {
```

```r
    loglikARMA[i] <- arima(all.ts.diff[, i + 2], order = c(2,
        0, 2))$loglik
    loglikRW[i] <- arima(all.ts.diff[, i + 2], order = c(0,
        0, 0))$loglik
    likRatioStat[i] <- 2 * (loglikARMA[i] - loglikRW[i])
    pvalue[i] <- pchisq(likRatioStat[i], 4, lower.tail = FALSE)
}
stargazer(cbind(c("AAPL", "XOM", "GOOG", "BRK_B", "WMT"),
    round(cbind(loglikARMA, loglikRW, likRatioStat,
        pvalue), digits = 4)), out = "n7_finance/arma.tex")

# =========================
```

Table 1:

	loglikARMA	loglikRW	likRatioStat	pvalue
AAPL	2215.4487	2215.117	0.6635	0.9558
XOM	2578.5023	2566.8419	23.3208	1e-04
GOOG	2306.5674	2305.8531	1.4287	0.8392
BRK_B	2542.1599	2509.2327	65.8545	0
WMT	2743.1107	2741.4459	3.3295	0.5043

The Capital Asset Pricing Model

1. Pick a rate of return for the risk free asset in our model. Justify your choice.

```
# Section 4: Risk free rate
# ========================

# The current 3 month us treasury bill rate is
# 0.03%, we the change this from an annual to a
# daily rate of return
rf <- (0.03/100 + 1)^(1/365) - 1


# ========================
```

2. For the 5 stocks, calculate; 1.) the mean returns, 2.) the covariance matrix of the returns of each firm and 3.) the covariance of the returns of each asset with the S&P500

Table 2:

	Optimal Portfolio	Mean return	Covariance w SP500
AAPL	0.218	0.001	0.00000
XOM	-0.051	0.0005	-0.00001
GOOG	0.207	0.001	0.00000
BRK	0.157	0.001	-0.00002
WMT	0.469	0.0005	-0.00001

Table 3:

	AAPL	XOM	GOOG	BRK	WMT
AAPL	0.0003	0.0001	0.0001	0.0001	0.00003
XOM	0.0001	0.0001	0.0001	0.0001	0.00004
GOOG	0.0001	0.0001	0.0002	0.0001	0.00004
BRK	0.0001	0.0001	0.0001	0.0002	0.0001
WMT	0.00003	0.00004	0.00004	0.0001	0.0001

3. Estimate the optimal portfolio of risky assets based only on these 5 stocks. Interpret your results.

```
# Section 5: Optimal Portfolio
# ========================

mu <- colMeans(all.ts.diff[, 3:7])  #Mean returns of 5 largest stocks
allcov <- cov(all.ts.diff[, 2:7])
rownames(allcov) <- c("SP500", "AAPL", "XOM", "GOOG",
    "BRK", "WMT")
colnames(allcov) <- rownames(allcov)
mktcov <- allcov[1, 2:6]  #How the 5 largest stocks covary with the SP500 index
sigma <- allcov[2:6, 2:6]  #How the 5 largest stocks covary with each other
sigma.inv <- solve(sigma)
```

```
# Calculates the sharpe optimal portfolio
optimal.portfolio <- sigma.inv %*% (mu - rf)/sum(sigma.inv %*%
    (mu - rf))

table1 <- cbind(optimal.portfolio, mu, mktcov)
colnames(table1) <- c("Optimal Portfolio", "Mean return",
    "Covariance w SP500")
stargazer(table1, out = "n7_finance/table1.tex")
stargazer(sigma, out = "n7_finance/cov.tex")


# ===========================
```

4. For each of the 5 stocks, run a regression of the excess returns of that stock on the excess returns of the S&P500. Present your results in a table.

```
# Section 6: Estimating Beta
# ===========================

excess.rtn <- all.ts.diff[, 2:7] - rf
names(excess.rtn) <- c("SP500", "AAPL", "XOM", "GOOG",
    "BRK", "WMT")
lmAAPL <- lm(excess.rtn$AAPL ~ excess.rtn$SP500)
lmXOM <- lm(excess.rtn$XOM ~ excess.rtn$SP500)
lmGOOG <- lm(excess.rtn$GOOG ~ excess.rtn$SP500)
lmBRK_B <- lm(excess.rtn$BRK ~ excess.rtn$SP500)
lmWMT <- lm(excess.rtn$WMT ~ excess.rtn$SP500)
stargazer(lmAAPL, lmXOM, lmGOOG, lmBRK_B, lmWMT, out = "n7_finance/regtable.tex")


# ===========================
```

Table 4:

	AAPL	XOM	GOOG	BRK	WMT
	Dependent variable:				
	(1)	(2)	(3)	(4)	(5)
SP500	0.049	-0.072^*	0.028	-0.237^{***}	-0.091^{***}
	(0.061)	(0.040)	(0.055)	(0.042)	(0.033)
Constant	0.001	0.001	0.001	0.001^*	0.001^*
	(0.001)	(0.0004)	(0.001)	(0.0004)	(0.0003)
Observations	844	844	844	844	844
R^2	0.001	0.004	0.0003	0.036	0.009
Adjusted R^2	-0.0004	0.003	-0.001	0.035	0.008
Residual Std. Error (df = 842)	0.018	0.012	0.016	0.012	0.009
F Statistic (df = 1; 842)	0.637	3.191^*	0.258	31.256^{***}	7.730^{***}

Note:	*p$<$0.1; **p$<$0.05; ***p$<$0.01

5. Give an interpretation to your regression. What does theory tell us the intercepts of these

regressions should be? What does theory tell us the coefficients of these regressions should be? How does this compare to our observed distribution of stock returns?

6. Discuss 3 limitations to the validity of the exercise we have performed.

Exploring Quandl

1. Browse through all the datasets on Quandl datasets at find one that interests you.

2. Produce a figure based on this dataset that shows something surprising and explain why you think this is interesting.

Side Projects

1. Estimating an option value: Using the empirical distribution of historic returns to Google stock, estimate the value of a european call option which expires in 20 days time and has a strike price 20% higher than the stock's current price. (3 points)

```
# Section 7: Side project on estimating option
# values ===========================

GOOG <- Quandl("GOOG/NASDAQ_GOOG", type = "raw", start.date,
    end.date, transform = "rdiff")

qplot(GOOG$Open)

qplot(GOOG$Open, binwidth = 0.01)
summary(GOOG$Open)
nPeriodReturn <- function(n, returns) {
    s <- sample(returns, n)
    s <- 1 + s
    return(prod(s))
}
ReturnDistn <- function(n, returns, sample.size = 1e+05) {
    z <- replicate(sample.size, nPeriodReturn(365,
        GOOG$Open))
    return(z)
}
CallOptionValue <- function(n, p, returns) {
    dstn <- ReturnDistn(n, returns)
    inMoney <- (dstn > p)
    value <- mean(inMoney * dstn)
    return(value)
}
CallOptionValue(365, 5, GOOG$Open)
```

2. Estimate an optimal risky portfolio Using all of the firms in the S&P 500. Discuss whether you would expect your results to be any different? Are your results any different? (2 points)

3. Redo this problem set in any other programming language supported by the quandl API. (2 points)

4. Go to nber.org or iza.org and find a paper published released in the last 3 months and write a 0.5-1 page summary for a non-technical audience (1.5 points, may be done twice, must be more than just their abstract reworded)

5. Read the following article and write a 0.5 - 1 page response. Evaluate the strength of their underlying economic arguements. For an additional point propose a way to test their idea with data http://www.nytimes.com/2014/05/15/upshot/the-role-of-student-debt-in-stunting-the-recovery.html?ref=business&_r=0 (up to 1.5 points + 1 point for additional idea)

6. Read the following article and write a 0.5 - 1 page response. Evaluate the strength of their underlying economic arguements. For an additional point propose a way to test their idea with data http://www.nytimes.com/2014/05/14/business/economy/the-politics-of-income-inequality.html?ref=business (1.5 points + 1 point for additional idea)

7. Read the following article and write a 0.5 - 1 page response. Evaluate the strength of their underlying economic arguements. For an additional point propose a way to test their idea with data http://www.nytimes.com/2014/05/14/business/economy/the-politics-of-income-inequality.html?ref=business (1.5 points + 1 point for additional idea)

8. Read the following article and write a 0.5 - 1 page response. Evaluate the strength of their underlying economic arguements. For an additional point propose a way to test their idea with data http://www.nytimes.com/2014/05/14/upshot/labor-market-seems-dented-not-broken.html?ref=business (1.5 points + 1 point for additional idea)