Financial Markets - 15.433 – Assignment #4
Professor Charles Hadlock

You should complete this assignment in a group of 3-6 students. The group should email a single copy of the assignment to (sloan15433ta@gmail.com) by **Tuesday, October 27th at 9:30 a.m.**. These exercises require some computer programming and you are free to use any language of your choice (Python, R, Matlab, Stata, or other). Your assignment should include a single pdf document that contains a summary of your tabulations from the computer/statistics work related to the exercises. You should then also include a document that includes your programming work and associated output. All questions related to the assignment should be directed to the course TAs. Please list all student names as they appear on Canvas along with your MIT ID numbers on the first page of your PDF submission.

Exercise #1

You manage an equity fund and your research team has recommended 5 stocks for possible investment. You are attempting to combine these 5 stocks into a portfolio that yields the most attractive risk-return proposition. These five stocks are: Exxon Mobil (XON\XOM), Procter & Gamble (PG), Pfizer (PFE), Walmart (WMT), and Intel (INTC). Monthly return data for these 5 stocks (in decimal form) and for the risk-free interest rate (taken as the 30-day T-bill rate) from Jan 1973–Dec 2019 is included in the assignment4a.xls spreadsheet. If we knew the 5x5 covariance matrix $\sum$ for these securities, and the expected 5 x1 excess return vector $\mathbf{r}$, our job would be easy, as we could simply apply the formula for the tangency portfolio and be done. Unfortunately, we need to estimate these key inputs, which creates many challenges as discussed in class.

(A) First approach: Estimating $\sum$ and $\mathbf{r}$ by the sample estimates. Use these sample estimates for $\sum$ and $\mathbf{r}$ to compute the tangency portfolio weights and minimum variance portfolio weights. How do the estimated expected excess returns and standard deviations of these portfolios compare? Since your estimate of $\mathbf{r}$ may be particularly sensitive to statistical noise, you wonder to what extent the portfolio weights are affected by small changes in these estimates. You decide to round your estimates of $\mathbf{r}$ to two decimal points (i.e., to the nearest percentage point) and recompute the tangency portfolio weights. From this evidence, does it appear that tangency portfolio weights are sensitive to estimation errors?

(B) Second approach: Assume $\sum$ is the identity matrix and continue to estimate $\mathbf{r}$ by the sample estimates. Calculate the tangency portfolio weights using these as your choices for $\sum$ and $\mathbf{r}$. Repeat the computation again rounding $\mathbf{r}$ to two decimal points.

(C) Third approach: Estimate $\mathbf{r}$ using the CAPM. You have estimated the following CAPM betas for the five stocks. Exxon Mobil beta=0.6, Procter & Gamble beta = 0.7, Pfizer beta = 1.2, Walmart beta = 0.9, and Intel beta=1.2. You expect the market risk premium in the future to be 0.5% per month. Using these estimates and the CAPM to form your estimate of $\mathbf{r}$, calculate the tangency portfolio weights. Do these weights appear to be more or less reasonable than what you found in part (A)?
(D) Fourth approach: Estimate $\sum$ and $\mathbf{r}$ by Bayesian/shrinkage techniques. As discussed in class, these techniques use weighted averages of the sample estimates as in part (A) combined with values of

$\sum$ and **r** that appear "reasonable" from an a priori perspective. The weights in this averaging process will generally depend on one's beliefs/judgment of the relative accuracy of the two sets of values. For now, we will keep it simple and place equal weights (i.e., half and half) on the estimated values and an alternative set of values. To derive **r** for this approach, use an equally weighted average of the estimated **r** vector from part (A) and the CAPM implied **r** vector from part (C). To derive $\sum$ for this approach, take the (element-by-element) equal weighted average of the estimated $\sum$ from part (A) and the diagonal matrix computed as $\bar{\sigma}^2 I$, where I is the identity matrix and $\bar{\sigma}^2$ is the simple average of the diagonal elements in the $\sum$ matrix part (A). Compute the weights in the tangency portfolio for this Bayesian approach.

(E) Out-of-sample evaluation. Up until this point, we have used the whole sample to construct the optimal portfolio. Thus, the portfolio weights derived in each part above could only be used starting in 2020. To gauge the actual performance of each of these approaches (often called an out-of-sample test), we will assume that a real-world investor has followed one of these approaches consistently over time, and we will look at which strategy has performed best.

To do this, start a fund in January 1978, which will give you an initial five-year period to estimate the inputs. Recompute the portfolio weights only once a year, as of January 1, for simplicity. Throughout the year, rebalance the portfolio to maintain the January 1 weights until the next January 1 when you can use an updated set of weights. Construct the series of returns on the four competing tangency portfolio selection strategies in parts (A) through (D) as follows. First, using the historical returns from the beginning of the sample to December 1977, construct the January 1, 1978 portfolio weights for a given selection strategy and record the excess returns implied by the strategy between January 1978 and December 1978. Next, augment the data with year 1978, so that your sample ends in December 1978, and recompute the tangency portfolio weights as of January 1, 1979. Obtain the resulting monthly excess returns of the portfolio, rebalanced monthly, over the months of 1979. Repeat this process until you reach the end of the sample. Once you have the January 1978-December 2019 returns implied by the four strategies, compare their average excess monthly returns and Sharpe ratios.

Exercise #2

In 1998 the management of Creative Computers (ticker = MALL, computer reseller) decided to spinoff their Ubid subsidiary (auction website), as they believed the Creative Computers stock price did not reflect the fundamental value of the parent and subsidiary combined. They announced their intentions on July 6, 1998 and planned to sell 20% of Ubid's equity to the public and planned to distribute the remaining 80% of Ubid to the shareholders of Creative Computers in a tax-free spin-off six months after the Ubid IPO. The UBid IPO was priced at $15 per share and its shares opened on 12/4/1998 at $38 and closed the first day at $48. In the spinoff, which was scheduled for 6/7/1999 after markets closed, each Creative Computer shareholder would get .7159 shares of Ubid plus they would maintain a share of Creative Computers (with Ubid then fully divorced from Creative Computers). The file assignment4b.xls contains data on the stock prices of both Creative Computer and Ubid during this episode.

You are a hedge fund and are looking at the prices of Ubid and Creative Computers a few days after the IPO on 12/9/1998 and are considering a long-short strategy that will surely generate profits if the spinoff occurs as planned on 6/7/1999. Assume that you will use all of the cash from the short position to purchase the long position, but that you must deposit with the broker arranging the short sale additional cash so that the cash deposited plus the value of the long position initially equals 110% of the short liability (i.e., 110% of the cost of covering the short position). You would establish this position at the closing prices of 12/9/1998. If the value of the long position decreases and/or the cost of covering the short position rises to the point where this ratio falls below 105% at any point in time, you will get a margin call and then you must either deposit additional funds to bring the account value back to 110% of the cost to cover the short position or else the entire position must be liquidated. Your fund has $20 million in total capital. Ignore any interest on cash.

(A) If you invested the full $20 million in a long-short strategy to profit from the relative mispricing of these shares and your broker agrees not to make any margin calls for 6 months (next we will examine whether this is reasonable), what would your profit be on 6/7/1999 if the spinoff occurs?

(B) If you took long and short positions equal to half of the number of shares you proposed in part (A) and deposited the full $20 million with the broker, would you have received a margin call at any point between 12/9/1998 and 6/7/1999 using the data in the spreadsheet. If so, what is the first date such a margin call would have occurred? Since you have no additional capital, assume the position would be closed on the date of a margin call. What would be your return when the position was closed?

(C) With the benefit of hindsight and your limited capital, what is the largest position you could have taken that would have avoided a margin call and what would be the return from this investment from 12/9/1998 to 6/7/1999?

<u>Exercise #3</u>

In September of 2001 Hewlett-Packard agreed to acquire Compaq Computer in a transaction in which each Compaq shareholder would receive .6325 newly issued shares of Hewlett-Packard when the deal was consummated. The plan was for the deal to be consummated after the close of trading on May 3, 2002. The file assignment4c.xls contains data on the stock prices of both Compaq and Hewlett-Packard during this episode.

You are a hedge fund that is quite confident the deal will be consummated at the announced terms and you are contemplating an investment a few days after the announcement. You are contemplating a long-short strategy that will surely generate profits if the deal closes as planned. Assume that you will use all of the cash from a short position to purchase the long position, but that you must deposit with the broker arranging the short sale additional cash so that the cash deposited plus the value of the long position initially equals 120% of the short liability (i.e., 120% of the cost of covering the short position). You would establish this position at the closing prices of 09/17/2001. If the value of the long position decreases and/or the cost of covering the short position rises to the point where this ratio falls below 110% at any point in time, you will get a margin call and then you must either deposit additional funds to bring the account value back to 120% of the cost to cover the short position or else the entire position must be liquidated. Your fund has at most $50 million in total capital to invest. Ignore any interest on cash.

With the benefit of hindsight and your limited capital, what is the largest position you could have taken that would have avoided a margin call and what would be the return from this investment have been from 09/17/2001 to 5/3/2002?