UNIVERSITY OF CHICAGO
Booth School of Business

Bus 35120 – Portfolio Management | Prof. Lubos Pastor

Assignment #4

Due: April 21 by 8:15am

Be as clear and brief as possible.

A.1. CASE STUDY: "The Dimensional Fund Advisors." Read pages 1-5 of the case. [Note: Next week, read pages 6-8 on DFA's trading, which we will discuss in class in Week 5. We are not going to discuss DFA's tax-managed funds (pages 9-10).] Answer the following questions.

1. Does DFA offer small-cap and value funds because it believes that small stocks and value stocks are undervalued?
2. Why did DFA start offering international funds?
3. Do you expect small stocks to outperform large stocks in the future? Value stocks to outperform growth stocks?

A.2. CASE STUDY: "Grantham, Mayo, Van Otterloo & Co." Read the case study and answer the following questions.

1. How does GMO's perspective on value investing differ from DFA's?
2. How does GMO construct its value and momentum subportfolios?
3. Does GMO suffer or benefit from the correlation between value and momentum?
4. Has GMO been successful with its investment strategy?

Be prepared to discuss both cases in class.

B. DATA ANALYSIS. The purpose of this assignment is to build and analyze optimal mean-variance portfolios with a focus on practical implementation issues.[1]

You manage an equity fund. Your research team has recommended five stocks for possible investment. You would like to combine these five stocks into a portfolio that yields the most attractive risk-return tradeoff. This is the tangency portfolio, whose five weights (which sum to one) are proportional to $V^{-1}E$, where E is the 5×1 vector of expected excess returns, and V^{-1} is the inverse of the 5×5 covariance matrix of returns, V. If you knew E and V, you would just plug these values in. But E and V need to be estimated, which presents interesting challenges.

[1] A MATLAB program that can help you produce the solutions can be downloaded from Canvas.

Download the Jan 1973–Dec 2016 monthly returns from WRDS[2] for the following stocks: Exxon Mobil (ticker XOM), Procter & Gamble (PG), Pfizer (PFE), Walmart (WMT), and Intel (INTC). After logging in to WRDS, go to Get Data, CRSP, Annual Update, Stock/Security Files, Monthly Stock File, and download the holding period returns for the five ticker symbols. Rearrange the data (e.g. in Excel) so that column 1 contains the dates (19730131 through 20161231) and columns 2 through 6 contain the returns on the five stocks (in the order XOM, PG, PFE, WMT, INTC). After eliminating any non-numerical text from the file, save it as "STOCK_RETS.txt". To compute excess stock returns, subtract monthly 30-day T-bill returns. After logging in to WRDS, go to CRSP, Annual Update, Index/Treasury and Inflation, and download the Jan 1973–Dec 2016 monthly returns on the 30-day Treasury bill (T30RET). After eliminating any text, save the file as "TB_7301_1612.txt".

1. **Estimating E and V by the sample estimates.**
   (a) Compute the sample estimates of E and V, denoted by $\hat{E}$ and $\hat{V}$.
   (b) Compute the tangency portfolio weights based on $\hat{E}$ and $\hat{V}$. Would you be willing to invest according to these weights?
   (c) How do the tangency portfolio weights compare to the weights in the minimum variance portfolio? How do the expected returns and variances of the two portfolios compare? Explain the differences.
   (d) Since $\hat{E}$ ($\hat{V}$ also, but less so) is affected by statistical noise, you might wonder to what extent the portfolio weights are affected by small changes in $\hat{E}$. Round $\hat{E}$ to two decimal places (i.e., to the nearest percentage point), and recompute the tangency portfolio weights using the rounded numbers.[3] How big are the differences in the weights due to rounding? Are the tangency portfolio weights sensitive to estimation errors?

2. **Estimating V by the identity matrix.**
   (a) Compute the tangency portfolio weights using the identity matrix I in place of V.[4] (To estimate E, continue using $\hat{E}$.)
   (b) How do these weights change if you round $\hat{E}$ to two decimal places as before? Is the effect stronger or weaker than in part 1? Why?

3. **Estimating E using the CAPM.**

   Your research team has estimated market β's for all five stocks: 0.6, 0.7, 1.2, 0.9, and 1.2, in the same order as before. Going forward, you expect the market premium to be 0.5% per month.

   Construct the 5×1 vector E_{CAPM} that contains the CAPM estimates of expected excess returns for each stock. Using E_{CAPM} and $\hat{V}$, what are the weights in the tangency portfolio? Do these weights look more or less reasonable than those from part 1?

[2] wrds.wharton.upenn.edu. I announced the username and password in class at the beginning of the quarter. If you have any difficulty in accessing WRDS, please contact Computing Services/HelpDesk.

[3] *Matlab hint:* Use the command *round* in a clever way.

[4] *Matlab hint:* If you want to generate an identity matrix, you can use the *eye* command, e.g., *eye(5)*.

4. **Estimating E and V using Bayesian/shrinkage techniques.**

   Bayesian techniques estimate E and V as weighted averages of the sample estimates ($\hat{E}$, $\hat{V}$) and the values of E and V that seem reasonable a priori. The weights for the weighted average should come from the data and from our prior beliefs (or judgment). We will use a simplified "shrinkage" version of the Bayesian approach, in which the weights for the average are taken as given.

   Construct the 5×1 vector E_B as a weighted average of $\hat{E}$ and E_{CAPM}, putting equal weights on $\hat{E}$ and E_{CAPM}. Construct the 5×5 matrix V_B as a weighted average of $\hat{V}$ and a diagonal matrix D, putting equal weights on $\hat{V}$ and D.[5] Make D proportional to the identity matrix I, so that $D = \bar{\sigma}^2 I$. Compute $\bar{\sigma}^2$ as a simple average of the diagonal elements of $\hat{V}$.[6] Using E_B and V_B, what are the weights in the tangency portfolio?

5. **Dynamic portfolio rebalancing.**

   So far, we have used the whole sample to construct the optimal portfolio for the next period. Next, we examine the actual ("out-of-sample") performance: We will assume that a real-world investor has followed one of these approaches consistently over time, and we will look which strategy has performed best.

   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, on January 1, for simplicity. Throughout the year, rebalance the portfolio to maintain the January 1 weights, until the next January 1 comes along. Construct the series of returns on the four competing investment strategies as follows.

   Using the historical returns from the beginning of the sample to December 1977, construct the January 1, 1978 portfolio weights as in questions 1 (using $\hat{E}$ and $\hat{V}$), 2 (using $\hat{E}$ and I), 3 (using E_{CAPM} and $\hat{V}$), and 4 (using E_B and V_B). Record the returns implied by these four strategies between January 1978 and December 1978. Next, augment the data with year 1978, so that your sample ends in December 1978. Compute the tangency portfolio weights for January 1, 1979 and record the portfolio's returns over 1979. Repeat this process until you reach the end of the sample. Once you have the January 1978-December 2016 returns implied by the three methods, compare their average returns and Sharpe ratios.

(continued on the following page)

[5] *Matlab hint:* An average of two matrices, $\hat{V}$ and D, is simply $0.5 * \hat{V} + 0.5 * D$.

[6] *Matlab hint:* The command *diag* picks out the diagonal elements of a matrix.

C. EXAM-LIKE QUESTIONS.

1. Consider two assets: a riskless one-year T-bill, and a risky asset whose annual Sharpe ratio is 0.7 and whose (simple) returns are normally distributed. Consider all two-asset portfolios that include both of these assets (short-selling is not allowed). For each portfolio, you can compute its shortfall probability (i.e., the probability that the portfolio will return less than the T-bill over the next year). What are the maximum and minimum shortfall probabilities, across all possible two-asset portfolios?

2. You are considering investing in one of two hedge funds. Fund 1 has an expected excess return of 18% and a Sharpe ratio of 1.0, and fund 2 has an expected excess return of 12% and a Sharpe ratio of 0.8. You care only about the mean and variance of asset returns, and you are risk-averse.

   (a) You can pick Fund 1 or Fund 2 (not both); which one do you pick? Does the answer depend on your attitude toward risk?

   (b) You can pick Fund 1 or Fund 2 (not both), and you can combine your choice with the T-bill in an arbitrary way. Which fund do you pick? Does the answer depend on your attitude toward risk?

3. Consider two assets, whose covariance matrix has two 0.05's on the main diagonal and two 0.01's off the diagonal. Find the combination of the two assets with the lowest possible standard deviation of returns.

4. Consider the same two assets, and assume their expected returns are 0.12 and 0.07. Suppose an investor's utility function is $U = E_P - 3\sigma_P^2$. Which combination of the two assets is optimal for this investor?

5. Consider the same two assets and the same investor, who can now also invest in the risk-free T-bill paying 0.02. What is the optimal portfolio of the three assets?

6. Other things equal, who should have a larger proportional stock allocation (relative to the T-bill allocation) in their retirement portfolios: an investment banker, or a tenured university professor?

7. **(not graded)** Read the following article from The Motley Fool. Explain why the author is confused.

Invest Like a Dead Poet
By Chuck Saletta
April 8, 2005

In the film Dead Poets Society, Professor Keating (Robin Williams) instructs his students to rip entire sections out of their poetry textbook and completely ignore what it says. "Carpe Diem" – seize the day – is his motto, and "suck the marrow out of life" is his philosophy. Poetry is more art than science – written to be enjoyed and "to woo women" – not to be analyzed under a microscope. The textbook that attempted to calculate values of "perfection" and "importance" to score poems? It was completely missing the point, and the value of the poetry itself.

As goes poetry, so goes investing

Just as the textbook "science" of poetry misses the point, so does the textbook "science" of investing. There is way more to investing than number crunching, and often, crunching the numbers leads to utterly ludicrous solutions. For example, I'm a big fan of diversification done right; it's protected my portfolio on numerous occasions. Yet the textbook teaching on diversification is shredder material, pure and simple.

The textbooks say that to achieve diversification, an investor must buy companies with a small or even negative correlation coefficient with one another, and by amassing a collection of such firms, an investor can be protected. Great theory, but in practice? Yuck. First, there's the heavy-duty math involved in calculating historical standard deviations and historical covariances. Then, there's the absolute nonsensical answers that often appear.

Nonsense from a textbook?

In the private Motley Fool Inside Value discussion forums, I recently ran through the calculations to illustrate the point. I figured out that, according to the textbooks, an investor would be better diversified buying Honda (NYSE: HMC) and General Motors (NYSE: GM) than buying Honda and Gillette (NYSE: G). That's right – according to the bogus number crunching that dominates Wall Street investment philosophies, an investor is better diversified buying two automakers than buying one auto manufacturer and one leading consumer products company. The correlation coefficient between Honda and GM was very close to zero, making them excellent candidates, whereas the correlation coefficient between Honda and Gillette was more than 0.8, indicating nearly identical historical movements, and therefore poor diversification protection.

Yet as a Fool, I know better. I know that, at the end of the day, Honda and General Motors both make cars. They compete for the same customers, rely on the same raw materials, and face the same market reality that their products are rarely "must have right now" kind of items. As an investor looking for diversification, I'd rather own one car manufacturer and one consumer products company than two of either, any day of the week.

Textbook diversification and its complicated and nonsensical calculations? To the shredder!

More shredder material

Diversification isn't the only place where the texts deserve to be shredded. Whether it's the classic Capital Asset Pricing Model or one of its newer multifactor cousins such as Fama French, the textbook risk and return calculations that dominate Wall Street all suffer from a fatal flaw: They all rely on historical stock price movements to predict what will happen next. I've said it before, and I'll say it again – the past is no prologue for the future; driving forward while looking in the rearview mirror is a great way to get into an accident.

Those models, no matter how much fancy math goes into them, say virtually nothing about the businesses behind the stocks. They wouldn't have told you to watch out for problems with donut baker Krispy Kreme (Nasdaq: KKD) and stun gun manufacturer Taser (Nasdaq: TASR) prior to their recent descents. A simple glance at those businesses and financial statements would have provided ample warning that the stocks had lost track of the companies' true values and their prices were eventually destined to fall.

Textbook analysis techniques based on stock price movements? To the shredder, you go!

(Note: The article goes on a little longer to advertize a particular investment strategy that is offering you a free 30-day trial, but I'll stop it here.)