Dr. Zamani
Graduate School of Management and Economics
Sharif University of Technology
Fall 2020

Financial Engineering

Problem set 1

Covering: Hall Textbook, chapters: 1,2,3

- Due date is Monday (99/7/28) midnight at 23:55.
- You should upload a file in CW, the names of which should be in the format of "FE-HW1-Student Number". If you also have an excel file compress both files and send a .zip or .rar file named with aforementioned format. Note that the only accepted format for your assignments is word or pdf, and any handwritten reports should be delivered in these formats.
- Score Reduction Policy:
  You are allowed a maximum of 7 days delay (in total) for the submission of all your assignments and your project. Note that the delay will be calculated "daily", not hourly (meaning that a 5-minute delay for a given assignment will be considered as 1 day).
- For the questions needing Excel (if any), also copy the tables of final answers (if it is not too big) in the Word/pdf file as well. Therefore, the Word/pdf file will have everything for all questions but the calculations will be in Excel. In other words, the Word file should be a standalone file.
- Personal integrity is the key to your success in career and life. Any cheating, dishonesty, or plagiarism will NOT be tolerated. If a student is found guilty of academic dishonesty, the student will receive an 'F' for the course in addition to any punishment determined by the university. You are allowed to consult with other students in solving the questions. However, all the work including problem sets and exams should reflect your effort only. **Too similar assignments will get zero, therefore, do not copy the result of others' efforts.**

---

1. Briefly explain the following concepts. In the cases of comparison, mentioning the difference is obligatory. (Sources such as: the textbook, various websites, and other textbooks could be used. Please write the references in the footnote.)
   a. Forward vs. futures contract
   b. Settlement vs. maintenance margin
   c. Stop vs. limit order
   d. Different types of traders (name them, also discuss their goals shortly)
   e. Convenience yield
   f. Open interest vs. trading volume
   g. Cross hedging

2. The attached file contains daily closing prices for the crude oil futures contract and the gold futures contract. You are required to answer the following:
    a. Assuming that daily price changes are normally distributed with zero mean, estimate the standard deviation of daily price changes. Calculate the standard deviation of two-day changes from the standard deviation of one-day changes assuming that changes are independent.
    b. Suppose that an exchange wants to set the margin requirement for a member with a long position in one contract so that it is 99% certain that the margin will not be wiped out by a two-day price move. (It chooses two days because it considers that it can take two days to close out a defaulting member.) How high does the margin have to be when the normal distribution assumption is made? Each contract is on 1,000 barrels of oil.
    c. Use the data to determine how often the margin of the member would actually be wiped out by a two-day price move. What do your results suggest about the appropriateness of the normal distribution assumption?
    d. Suppose that for retail clients the maintenance margin is equal to the amount calculated in (b) and is 75% of the initial margin. How frequently would the balance in the account of a client with a long position be negative immediately before a margin payment is due (so that the client has an incentive to default)? Assume that balances in excess of the initial margin are withdrawn by the client.

3. A trader owns 60,000 units of a particular asset and decides to hedge the value of her position with futures contracts on another related asset. Each futures contract is on 4,000 units. The spot price of the asset that is owned is $25 and the standard deviation of the change in this price over the life of the hedge is estimated to be $0.41. The futures price of the related asset is $23 and the standard deviation of the change of it over the life of the hedge is $0.39. The coefficient of correlation between the spot price change and futures price change is 0.93.
    a. What is the minimum variance hedge ratio?
    b. Should the hedger take a long or short futures position?
    c. What is the optimal number of futures contracts when adjustments for daily settlement are not considered?
    d. How can the daily settlement of futures contracts be taken into account?

4. A fund manager has a portfolio worth $180 million with a beta of 0.82. The manager is concerned about the performance of the market over the next 2 months and plans to use 3-month futures contracts on the S&P 500 to hedge the risk. The current level of the index is 1200, one contract is on 250 times the index, the risk-free rate is 9% per annum, and the dividend yield on the index is 4.5% per annum. The current 3-month futures price is 1210.
    a. What position should the fund manager take to hedge all exposure to the market over the next 2 months?
    b. Calculate the effect of your strategy on the fund manager's returns if the index in 2 months is 1400, 1300, 1200, 1100, and 1000. Assume that the 1-month futures price is 0.25% higher than the index level at this time.

5. Suppose that there are no storage costs for crude oil and the interest rate for borrowing or lending is 4% per annum. How could you make money if the June and December futures contracts for a particular year trade at $50 and $56, respectively?

6. Write a program in Python or R (preferably Python), in order to, meet the following requests: Consider a 1-year forward contract on a stock. Assume that the risk-free rate of interest (continuously compounded) is chosen from a uniform distribution between 7% and 10% per annum for all maturities and also that the stock price of S_0 , which has a normal distribution with mean $46 and standard deviation $9, is expected after t month, which t has the same probability to be 3, 6 or 12. We know that the forward price for this security is $52. Repeat aforementioned steps 1000 times. (There is no obligation to write this with for loop)
    a. Plot a histogram for stock prices for 1000 iterations. ($50 > n_{bins} > 20$)
    b. Plot a histogram for arbitrage profits for 1000 iterations.
    c. Determine the trading strategy based on arbitrage opportunity. (print the strategy for last iteration, sell which one at price X, buy which one at price Y)