NOVA SCHOOL OF
BUSINESS & ECONOMICS

2024/2025 S1

Investments

Assignment

Professors:

Giorgio Ottonello

Nicholas H. Hirschey

Rules

1. We kindly ask you to direct any questions you may have to the appropriate Moodle forum. The graders will regularly check and answer questions via Moodle, so that everyone has access to the same information set.

2. Upload your files through Moodle before the deadline (i.e., **November 22, 2024 at 23:59**).

    - The written document for each group of five students may not exceed **five pages** (Times New Roman; 12pt font; 1.5 line spacing; normal margins). This limit excludes the cover page and the appendix.

    - The tables and graphs are to be collected in an appendix. The tables should be numbered and have a short heading. For example:

Table 1: This table gives an example of what a table should look like. It reports the alphas and betas of two industries – Industry 1 and Industry 2.		
	Industry 1	*Industry 2*
Alpha	1	2
Beta	2	3

    - These rules are strict. The grader will only consider the first **five pages** of answers to the questions asked below and will consider only correctly referenced and formatted tables.

    - In addition to the written report, you should also upload your calculations file (e.g., Excel file) via Moodle.

3. This assignment counts towards 20% of your final grade!

Part 1 – The Setting

You are thinking of investing in fixed income securities. In order to construct your portfolio, you need to perform a qualitative and quantitative analysis of the available investment opportunities.

- In this assignment, you analyze data over two dates. Assume we are on October 10th of 2024, this is the first date. The second date is six months later: April 10th of 2025.
- All the additional data you need is in the Assignment_2024_data.xlsx file.
- For all bonds, assume that coupon payments occur the same day of the month as in the maturity date (e.g. if the maturity date is 17-08-2025, payments are due on the 17th of the month).

Part 1 - Questions

For starters, analyze the available Treasury bonds and notes.

1. Using the available maturities, graph both the current (10/2024) Treasury yield curve and the same curve in 6 months (4/2025). Calculate the changes in yields for each maturity and graph them. Describe and comment how the shape of the yield curve changes.

2. Using the spot rates as of today (10/2024), calculate the 6-month forward rates for the maturities from 6 months to 6½ years (in case you need yields that are not given, please use a linear interpolation – when possible[1]). Using the forward rates you calculated, compute the expected prices of the same 1Y, 2Y, 5Y bonds in six months.

In order to benefit from diversification, suppose you want to add some corporate bonds to your portfolio. You need to study the available investments.

3. Graph the current yield curve for Company A in the same graph as the Treasury curve for the same date (10/2024). Calculate the corporate spread as a function of maturities. What variables can help to explain the corporate spread? Calculate the dirty (invoice) price for each Company

[1] For $t_{i-1} < t < t_i$ the linear interpolation formula is: $r(t) = \frac{t-t_{i-1}}{t_i-t_{i-1}} r(t_i) + \frac{t_i-t}{t_i-t_{i-1}} r(t_{i-1})$

A bond on October 2024. To compute the number of days, use the US 30-day method with a 360-day year (30/360 convention).

4. Compute the duration and convexity for each Treasury and Company A bond as of today (10/2024). Explain why you observe differences in duration for bonds with the same maturity. Using the observed change in yields between the two dates, compare the actual change in Treasury bond prices between 10/2024 and 4/2025 with the predicted change obtained using:

    a. the duration approximation;
    b. the convexity rule.

    Comment on your results.

5. Consider now that the company IAG wants to issue £500M in corporate debt with 7 years to maturity. At current market conditions, the company can issue at par value of £100 a plain-vanilla corporate bond with semi-annual payments and an annual coupon rate of 6.375%. Due to the recent demand on the derivatives market, the CFO wants to explore the idea of issuing a convertible bond with 7 years to maturity.
    a. Consider the information below for the stock of IAG and calculate the value of the European call option component of the bond, and annual coupon rate of the bond if the firm wants to issue the convertible at par value of £100, with a conversion ratio of 10/1. Please consider that the bond continues to have semi-annual payments. Use the Black-Scholes formula to value the option.

Stock price	Annualized historical volatility	Annualized implied volatility
£4.82	72.435%	62.432%

    b. Imagine that put options on the stock of the company IAG are traded with 7 years to maturity like in the table below. Is there an arbitrage opportunity? If so, calculate the arbitrage profit. In reality, what elements should you take into consideration before exploiting the possible arbitrage?

Strike	£5	£7.50	£10	£15	£20
Put price	£0.43	£3.02	£5.43	£12.10	£17.87

c. The CFO is afraid that the instrument might bring too much stock dilution for the equity holders and so he wants to include a cap feature in the prior call option (the option will be capped if it reaches a certain level). Adding the cap feature, the option's payoff becomes:
    - C = (Capped Level - K) if S > Capped Level
    - C = Max (0; S – K) if S <= Capped Level

Calculate the price of the option as of 10/2024, assuming that the capped level is £14.25. If the company still wants to issue the convertible bond at £100, what is the new coupon rate?

Use a binomial tree approximation (with annual steps) and remember that option pricing models often assume movements in the underlying stock price equal to $S_u = S_0 e^{\sigma\sqrt{T}}$, $S_d = S_0 e^{-\sigma\sqrt{T}}$ for up and down movements, respectively. Where, S_0 is the stock price today, T is in number of years until expiration and σ the annualized estimation for volatility.

d. What is the equivalent number of stocks that IAG would have to issue if instead of selling convertible bonds, the firm decided to issue plain-vanilla debt (and issue stock), but still wanted to face an equivalent financing structure (in terms of delta exposure) as using:
    - Convertible bonds without capped feature (like in Part A)
    - Convertible bonds with capped feature (like in Part C)

Part 2 – Data

Each group analyzes a different set of ten industries, which depend on your group number. One of these 10 is of particular interest ("**Principal Industry**"). You will use all 10 industries for your analysis. Additionally, there is an 11th industry in the last column ("**Extra Industry**") that will only be used in one question.

The industry allocation is presented in the sheet "Industry allocation per group" of the Excel file. Industries are indexed by number, and you can see the mapping between industry number and industry name at the top of the "Returns" sheet of the assignment excel file (1 = "Agric", 2 = "Food", etc). For instance, if your industry index is "1,2,3,4,5,6,7,8,9,10," then you will analyze Agriculture, Food (Food Products), Soda (Candy & Soda), Beer (Beer & Liquor), Smoke (Tobacco Products), Toys (Recreation), Fun (Entertainment), Books (Printing and Publishing), Hshld (Consumer Goods), and Clths (Apparel).

Moreover, you should not re-arrange the order of your industries – e.g., if your industry index is "5,30,25,10,18,2,6,3,44,9", then keep this particular order across all tables. If you ignore this instruction and rearrange the order, then your answers may not match our solution for your group and you could lose points. So don't do it.

For each industry, value-weighted returns are presented in the sheet "Return."

The one-month T-bill return ("**RF**"), the excess market return ("**MKT-RF**," calculated as the value-weighted average excess return of all stocks traded in the United States), and the remaining factors for the Fama-French-Carhart four-factor and Fama-French five-factor model are presented in the sheet "Factors."[2] [3]

In this assignment, you will analyze data over two periods.

- There is an **in-sample period** from 1995 to 2017.
- There is a **holdout (out-of-sample)** period from 2018 to 2023.

Each question says whether you should use the in-sample period or holdout sample period. The holdout period is used to test whether the performance of investment strategies over the in-sample

[2] Throughout this assignment, you may sometimes need to use excess returns (i.e., returns in excess of the t-bill return) and oftentimes you may need to use total returns. You should read the questions carefully to make sure that you are using the right one, as the distinction is important economically.

[3] Note, a return of -99.99 means the return is missing for that month. Also, for increased convenience, divide all returns by 100 to have them in percentage terms.

period extends out-of-sample. This method of backtesting is popular in the industry to determine the usefulness of trading strategies in a real-world settings.

Part 2 – Questions

1. Start by performing the following tasks using data from the in-sample period.
    a. Plot the cumulative return of your principal industry and the market portfolio.
    b. In the cumulative returns' plot, you may see that the value of your industry varies dramatically over time. In the context of the dividend discount model, this variation comes from the incorporation of news about future dividends and/or the discount rate "r" into stock prices. Identify two events that had a relevant impact on the valuation of your principal industry and justify why.
    c. Calculate the CAPM beta for your ten industries and discuss their systematic risk, while considering the fundamental characteristics of the industries.

2. For this question use data from the in-sample period. Plot the mean-variance efficient frontier of the ten industries portfolios assigned to your group in a chart. Also present the Capital Allocation Line in the same chart.

3. Using data from the in-sample period, what is the optimal portfolio for a mean-variance investor that desires an expected return of 8% per year? Do this for each of following three investment universes:
    a. Ten industries and the risk-free asset (11 total assets), long and short positions allowed.
    b. Ten industries and the risk-free asset (11 total assets), only long positions allowed. No short-selling.
    c. Ten industries and the risk-free asset (11 total assets), with long and short positions allowed, but each industry's weight must be constrained to between -25% and 25% of the total portfolio.
    d. Ten industries, the risk-free asset, and the "Extra Industry" (12 assets), long and short positions allowed.

Then discuss:

    e. How do the weights on the assets vary across the four different portfolios? Why do they vary, and what do you learn from the differences?

f. How does the shape of the efficient frontier change when you change the investment universes in parts a., b., c., and d.? Describe and interpret the changes.
g. What are the Sharpe ratios of these four portfolios? What do the Sharpe ratios imply about the relative attractiveness of these portfolios to mean-variance investors? How does limiting portfolio weights in parts b. and c. affect the Sharpe Ratio of this portfolio compared with part a. that has no restrictions?
h. How does adding one industry in part d. affect the Sharpe Ratio of this portfolio compared with part a. with only 10 industries? Interpret the difference.

4. Form and analyze an industry time-series momentum (Hurst, Ooi, Pedersen (2013)) long-short portfolio that selects industries based not only on returns but also on their recent volatility. For this question use data from the in-sample period:
    a. For each industry, calculate its trailing 12-month standard deviation (σ_t) and trailing 12-month cumulative excess return ($r_{t-12,t}$). For instance, in January 2024, the trailing 12-month standard deviation will use data from the 12 months starting January 2023 and ending December 2023.
    b. For each industry, calculate its time-series momentum return in month *t* as $r_t^{TSMOM,i} = sign\left(r_{t-12,t}\right)\frac{40\%}{\sigma_t}r_t$ where r_t is the industries excess return in month *t* and $sign\left(r_{t-12,t}\right)$ is +1 if $r_{t-12,t}$ is positive and -1 if it is negative (the 40% scaling factor means the position has an ex-ante volatility of 40%, but once we diversify across industries the portfolio standard deviation should be lower). Thus if in January 2024 an industry has a 20% trailing standard deviation, 12% trailing cumulative excess return, and the January excess return is 4%, the time-series momentum return for that industry position is $+1 \times \frac{40\%}{20\%} \times 4\% = 8\%$. If instead the trailing cumulative return was negative, the time-series momentum return would be-8%. Now average across all industries $\left(r_t^{TSMOM} = \frac{1}{10}\Sigma_{i=1}^{10} r_t^{TSMOM,i}\right)$. This is your industry time-series momentum portfolio.

    c. Estimate the CAPM and Fama-French + MOM 4-factor (RmRf, SMB, HML, MOM) models for the industry time-series momentum portfolio. Discuss the

economic and statistical magnitude of the alphas and betas. What are the information ratios, and how do we interpret them? Comment on any differences you find moving from the CAPM to the FF3+MOM factor model.

5. Compare the out-of-sample (holdout period) performance of the following portfolios. For this purpose, present the following performance statistics: average excess return, standard deviation, and Sharpe ratio. Then, discuss what you find interesting in this comparison:
   a. Portfolio from question 3.a,
   b. Portfolio from question 3.c,
   c. Industry time-series momentum portfolio from question 5,
   d. Equal-weight portfolio of the ten industries. Note: an equal-weight portfolio can generate lots of trading if it is rebalanced frequently. To produce a more passive portfolio, please only rebalance it back to equal weights annually at the end of each calendar year. Thus the portfolio will only be exactly equal-weight in January; in other months, industries that performed well earlier in the year will end up with higher weights because you haven't rebalanced yet.
   e. Market portfolio.

6. Considering your analysis of the industry portfolios, discuss the broader implications of your findings for the debate between active and passive investing. Specifically, evaluate whether the performance of your active strategies, such as momentum-based or mean-variance optimization-based portfolios, justifies their increased complexity, higher transaction costs, and potential for higher returns compared to the simple passive strategies like the equal-weighted portfolio or market portfolio. Based on your results, what are important considerations when evaluating active versus passive strategies?