Problem Set 1: Building an Asset Pricing Model

California Institute of Technology
BEM 114: Hedge Funds
Spring 2025

Due: April 11, 2025

Introduction

In this homework assignment you are asked to build a model for evaluating hedge fund performance. There is a file on Canvas called "ps1_strategies.csv" which contains time-series returns for several trading strategies. The returns are presented as **excess returns**, that is, $R_p - R_f$. We'll refer to this as the "strategies dataset." In this problem set you will build a tool for analyzing these strategies.

Submission Instructions and Tips

I recommend you complete the assignment using Python, but you are free to answer the questions in the programming language of your choice. Please submit your assignments on Canvas before 11:59 p.m. on the due date. Please upload a PDF file with your answers, as well as your code. For example, if you complete the assignment in an iPython notebook, please submit a PDF of the notebook and the notebook itself.

If you complete the assignment in Python then you may find the following packages useful:

- pandas: This package is helpful for storing and manipulating portfolio return data. The strategies dataset and the factor dataset can be read directly in as a pandas dataframe. Pandas was designed by a software developer at a hedge fund explicitly to deal with financial market data. It will be a useful tool for future problem sets.
- statsmodels: This package is helpful for estimating the CAPM model. In particular, you can use the OLS function to estimate the regression of portfolio excess returns on market excess returns. Do not forget the intercept term, which is needed to estimate alphas.

You are free to consult Chat-GPT or other LLMs to help with your code. These can be immensely helpful learning tools and may help develop your intuition on how to code efficiently in Python. This will be particularly important in later problem sets when we work with larger datasets.

Questions

1. **Build a Simple Analysis Tool**: Recall that under the CAPM, portfolio returns can be described by the following linear relationship:

$$R_p - R_f = \alpha_p + \beta_p(R_M - R_f) + \varepsilon_p$$

   Download the monthly Fama French 3-factors from Ken French's website.[1] The factor file contains historical data on the market risk premium ($Mkt - RF$, here $R_M - R_f$) and the risk-free rate (RF, here R_f). It also contains other important asset pricing factors (SMB and HML) that we will revisit later in Problem Set 2.

[1] `https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`

(a) (5 points) Calculate the average monthly return, volatility, and Sharpe ratio of the market portfolio. Note: the data files list excess returns, for instance $R_M - R_f$. You'll need to add back in the risk free rate when calculating means and plotting.

(b) (5 points) Calculate the average monthly return, volatility, and Sharpe ratio of the "constant alpha" (CA) strategy from the strategies dataset.

(c) (20 points) Build a function that estimates the CAPM for given a given excess-return series.

(d) (5 points) Estimate the CAPM for the CA strategy.

(e) (5 points) Calculate the CAPM implied returns using only the estimated beta:

$$\hat{R}_p = R_f + \hat{\beta}_p(R_M - R_f)$$

(f) (5 points) On the same figure plot cumulative:

1. Market returns,
2. Strategy returns,
3. Model-implied strategy returns.

(g) (5 points) Based on this initial analysis, do you think the CA strategy would make a good hedge fund strategy, why or why not?

Total for Question 1: 50

2. **Evaluating Returns**: We now have a tool for analyzing the performance of any hedge fund. In this question we will use our tool to analyze various strategy returns. When answering these questions, you may want to repeat the analysis in Q1. In particular, calculating average returns, volatility, Sharpe ratios, estimating the CAPM, and calculating and plotting cumulative market, strategy, and model-implied strategy returns. You don't need to report all of the results, but be sure to support each answer using a quantitative analysis. When answering Question 2, assume that these are **after-fee** returns.

(a) (5 points) Does the "low beta high alpha" strategy (LBHA) beat the market? Why or why not?

(b) (5 points) Does the "late start alpha" strategy (LSA) produce positive and significant alpha at the 5% level? What concerns might a client have over this strategy? How could you allay those concerns?

(c) (5 points) Does the "tapering alpha" strategy (TA) produce positive and significant alpha at the 5% level? Is this a strategy that investors would be interested in? Why or why not?

(d) (5 points) Between the "high volatility" (HV) and "low volatility" (LV) strategies, which would a client prefer? Why?

(e) (5 points) Suppose after months of work you generate the "negative alpha" (NA) strategy. You estimate the alpha and it is negative and significant. Was all this work for nothing? Why or why not?

(f) (5 points) Which hedge fund manager is "better," the one that offers the "low beta" strategy (LB) or the "high beta" strategy (HB)? Why?

Total for Question 2: 30

3. **Fees**: Consider two hedge funds, both with a "1.8 and 20" fee structure. Suppose the before-fee returns are given by strategies LB and HB, and that the 1.8% management fee is earned equally each month. That is, a management fee of $\frac{1.8}{12} = 0.15\%$ is taken off each month. The incentive fee of 20% is taken off each month, but is only earned if the cumulative value in the fund is greater than the previous maximum, and is earned on the difference between the current value and the maximum. That is, incentive fee is $0.2 \max(0, CV - MV)$, where CV is the current value and MV is the max value.

   (a) (5 points) Calculate before-fee alphas and betas.

   (b) (5 points) Calculate the after-fee alpha and betas.

   (c) (5 points) Suppose a client invests \$100 million in each strategy. Calculate the total fees paid to each strategy. Which has higher fees, why?

   (d) (10 points) Clients value hedge funds because of alpha, but fees are paid based on absolute returns. For instance, in this question we have seen that high betas lead to higher returns and higher fees. Some of the best performing hedge funds in the world have high market betas, why do you think this is the case?

Total for Question 3: 25