**MFIN7034 Problem Set 2 – Factor and Portfolio Analysis**

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In this problem set, you will write codes to explore traditional portfolio analysis methodologies in the real world scenarios. Also you will conduct in-depth study towards cross-sectional asset pricing factor analysis.

**Submission format: .ipynb notebook with runnable code and all the steps shown, and a PDF report.** The final report should contain results generated by your program. Simple, presentable, coherent English, clean graphs. Proper visualization and clear interpretations & discussions, such as explaining why your method with Fama-Macbeth regression can compare risk premiums and factor models, will also be graded.

**1. Portfolio Analysis (60 Marks)**

An endowment is currently investing 80% in a market-index fund and 20% in the risk-free asset until recently the optimal allocation. The endowment’s investment committee is considering the potential benefits of adding portfolios that provide exposure to segments of the market grouped by firms’ market capitalizations (big v.s. small) and book-to-market ratios (value v.s. growth). Assume a risk-free interest rate (for lending or borrowing) equal to 0.3 (in percent) per month.

Specifically, the committee is considering the potential addition of four portfolios to the fund’s investment universe: small-cap growth portfolio, small-cap value portfolio, large-cap growth portfolio and large-cap value portfolio. The dataset “portfolio\_return\_series.csv” is available to you on Moodle. Returns are from the end of January 1982 through the end of September 2019 at the monthly frequency (values are in percentage).

The committee is also considering whether to add the above portfolios in a long-only capacity or whether allocations involving short positions are sufficiently more attractive to justify going in that direction. Finally, some committee members note that small-cap stocks are substantially riskier, and they wonder whether excluding the two small-cap portfolios above would significantly limit the endowment’s investment opportunities.

**1.1 Certainty Equivalent Rate of Return (15 Marks)**

The endowment has the following mean-variance objective function in the form:

where U is the investment’s certainty-equivalent rate of return, and A is the endowment’s degree of risk aversion. Now it has been known that the endowment’s degree of risk aversion is such that the current allocation between the market index and risk-free asset is optimal for the endowment when the investment universe is restricted to only those two assets. Find the corresponding value of A (a simple derivative calculation). After obtaining the value of A, further plot the certainty-equivalent rate of return graph with x-axis as the weight in the market index (weight within the range [0, 1]).

**1.2 Efficient Frontier and Tangent Portfolio (30 Marks)**

The committee is interested in learning the potential attractiveness of the following four scenarios from a mean-variance perspective (risk-free asset is always eligible):

|  |  |  |  |
| --- | --- | --- | --- |
|  | Eligible risky assets | Constraints on risky asset weights | Constraints on borrowing/lending |
| 1 | Market index, large-cap growth, large-cap value | Long only | No borrowing allowed |
| 2 | Market index, large-cap growth, large-cap value | Weight on each asset between -0.5 and 1.5 | No constraint on borrowing/lending |
| 3 | Market index, large-cap growth, large-cap value, small-cap growth, small-cap value | Long only | No borrowing allowed |
| 4 | Market index, large-cap growth, large-cap value, small-cap growth, small-cap value | Weight on each asset between -0.5 and 1.5 | No constraint on borrowing/lending |

For each of the above four scenarios:

1. Plot the Markowitz efficient frontier (via 10,000 simulations), as well as each risky asset’s location in the graph
2. Output the tangent portfolio weights for each eligible risky asset
3. Draw the capital allocation line

**1.3 Overall Review (15 Marks)**

In an overall summary of the results you obtained across the four scenarios, comment on whether the additional portfolios appear to offer the endowment substantial benefits over the existing allocation, from the perspective of: 1. Sharpe ratio; 2. Certainty equivalent rate of return.

If there are substantial benefits, comment on which added dimensions (i.e., market-cap tilts, value/growth tilts, shorting) appear most responsible for the largest improvement.

**2. Factor Zoo Deeper Explorations (40 Marks)**

Review what we have covered in Problem Set 1: We conducted Fama-Macbeth regression analysis to test the magnitude and direction for each cross-sectional factor covered in the three prevalent factor models. You may notice that most of these factors are based on firm fundamental information. Very few cross-sectional factors irrelevant to firm fundamentals are constructed based on trading information, such as momentum/reversal and (il)liquidity. Nowadays there have been over 400 factors towards the equity market, also known as “Factor Zoo”.

In this question we shall try to explore more factors beyond what we have covered in Problem Set 1. Most firms’ fundamental information are updated quarterly (seasonal report) or annually (annual report). Quarterly fundamental information can be accessed and downloaded via [Fundamentals Quarterly](https://wrds-www.wharton.upenn.edu/pages/get-data/center-research-security-prices-crsp/annual-update/crspcompustat-merged/fundamentals-quarterly/); annual fundamental information can be accessed and downloaded via [Fundamentals Annual](https://wrds-www.wharton.upenn.edu/pages/get-data/center-research-security-prices-crsp/annual-update/crspcompustat-merged/fundamentals-annual/).

You only need to focus on firms covered in the Problem Set 1 dataset. To construct a factor monthly return series, you need to do the following:

1. At one month t, find all values of the most updated fundamental measurement
2. Sort all firms based on the fundamental measurement (ascending or descending both are fine, as long as you remember that XD)
3. Calculate the **top 20%** firms’ average monthly return (**equal-weight**), minus the **bottom 20%** firms’ average monthly return (**also equal-weight**) to obtain the factor’s monthly return at month t

**2.1 Trials! (25 Marks)**

Based on the provided two data sources, download the data you prefer, and construct 5 factors on your own. You may freely choose what firm fundamental information you want to use, but illustrate why you think the fundamental information you choose might be able to explain the cross-sectional asset return.

**2.2 Why is Fama-Macbeth Regression Famous? (15 Marks)**

Fama-Macbeth is not only the tool to estimate the magniture and direction for each factor within one factor model, but it could also help to test the significance of each factor in the entire factor model, as well as to compare different factor models in explaining asset returns. We would suggest you carefully review the reference provided in Problem Set 1: [Prepared\_1Nov2022.pdf](https://www3.nd.edu/~nmark/FinancialEconometrics/2022Course/CourseNotes/Prepared_1Nov2022.pdf).

There are two possible ways with Fama-Macbeth regression to compare your newly constructed factors with the old, famous factors covered in Problem Set 1. Please discuss your idea and thoughts, conduct your analysis and summarize your results. The mark of this question will be given very generously, so just bravely give a try!