

Asset Management Project

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Abstract

This project analyzes monthly returns of five S&P 500 stocks. Estimates historical means and covariances using exponential averaging and a shrinkage approach. Efficient frontiers are constructed with and without portfolio constraints. CAPM is used to evaluate alpha and beta, and the Black-Litterman model is applied to incorporate market-implied returns and investor views into portfolio optimization.

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Requests

You are given a dataset of monthly total returns of 5 US stocks of the S&P 500 index. Use only the stocks assigned to your group in the analysis.

1. Provide a brief description of each of the stocks included in your dataset (maximum 2 lines per stock). E.g., sector, company structure, and balance sheet data (use information available online).
2. Estimate the historical mean and variance-covariance matrix of the stocks in your dataset with the methods described below. Estimate the variance-covariance matrix with a Shrinkage toward Constant Correlation Approach (consider $k = 0.35$). Estimate the vector of averages with an exponential average ($\lambda = 0.02$). Comment on the correlations among the stocks observed in your dataset.
3. Plot the efficient portfolio frontier (in the standard deviation-mean space) with a risk-free asset (with annual return $R_f = 0.03$). Comment on the obtained tangent portfolio (or risky asset portfolio).
4. Plot the efficient portfolio frontier (in the standard deviation-mean space) with the same risky and risk-free assets but imposing two different constraints:
 - the sum of portfolio weights of the first and second stock in your dataset is equal to 50%.
 - the portfolio weights are above 10% for each stock.

Comment on the differences on the frontier portfolio with 0.5% monthly expected return with and without the two constraints (you should consider three different frontiers: no constraint, constraint 1, and constraint 2).

5. Estimate CAPM alpha and beta for your stocks, using the returns of the S&P 500 (you should obtain returns from S&P 500 prices) as a proxy for the market returns. Comment on the results: which of the stocks has generated alpha in the previous years? Assume $R_f = 0.02$.
6. Compute market implicit returns Π in a Black-Litterman framework and compute the market portfolio (assuming that the market comprises only your 6 stocks).
7. Formulate at least two Black-Litterman views for the returns of the stocks in your portfolio for January 2025 (for formulating the views, you can use historical averages, news, and/or

public balance sheet data). Comment on the Black-Litterman portfolio obtained when considering your views.

8. *Facultative:* design a similar way to incorporate the views based on the tracking error variance frontier.

1 Stocks descriptions

- **Broadridge Financial Solutions:** primarily focuses on providing proxy statements and annual reports to institutions and in 2023 it achieved an income of 0.63 billion dollars.
- **Berkshire Hathaway:** is a conglomerate involved in industries, including insurance and significant investments, in various companies across different sectors, recording a net income of 96.22 billion in 2023.
- **Caesars Entertainment:** primarily focuses on owning and operating casinos and resorts, along with entertainment facilities of all sorts, and generated a net income of 0.79 billion in 2023.
- **PPG Industries:** creates paints and coatings for different industries like construction and automotive, reporting a net income of 1.27 billion in 2023.
- **Prudential Financial:** offers insurance and investment services to individuals and institutions and reported an income of 2.49 billion in 2023.

2 Statistics values

In the second point we calculated the historical average of logarithmic daily returns since the first common date and the results were as follows: 1.51% for Broadridge, 0.93% for Berkshire, 1.98% for Caesars Ent., 0.16% for PPG Ind. and finally 0.39% for Prudential Fin. We then calculated the variance-covariance matrix (Figure 2.2) and the correlation matrix (Figure 2.1):

Correlation Matrix:						Variance - Covariance Matrix:					
	BR	BRKb	CZR	PPG	PRU		BR	BRKb	CZR	PPG	PRU
BR	1.000000	0.441655	0.414259	0.523736	0.386517	BR	0.004017	0.001411	0.005074	0.002410	0.002046
BRKb	0.441655	1.000000	0.439054	0.624260	0.675080	BRKb	0.001411	0.002540	0.004277	0.002284	0.002841
CZR	0.414259	0.439054	1.000000	0.491739	0.596371	CZR	0.005074	0.004277	0.037352	0.006980	0.009624
PPG	0.523736	0.624260	0.491739	1.000000	0.600151	PPG	0.002410	0.002284	0.006980	0.005271	0.003638
PRU	0.386517	0.675080	0.596371	0.600151	1.000000	PRU	0.002046	0.002841	0.009624	0.003638	0.006973

Figure 2.1

Figure 2.2

There is a positive correlation between all stocks which fluctuates around 0.5 but never gets too close to one, suggesting that they are very different companies. The two most correlated companies are Berkshire and Prudential Fin. with a correlation of about 0.68, which makes sense considering that they both work in the capital management sector. We then calculated the variance-covariance matrix at constant correlation with a k of 0.35 (Figure 2.3) And estimated the vector of averages with an exponential mean with λ equal to 0.02 (Figure 2.4):

	BR	BRKb	CZR	PPG	PRU
BR	0.004017	0.001498	0.005524	0.002403	0.002291
BRKb	0.001498	0.002540	0.004550	0.002150	0.002612
CZR	0.005524	0.004550	0.037352	0.007035	0.009189
PPG	0.002403	0.002150	0.007035	0.005271	0.003467
PRU	0.002291	0.002612	0.009189	0.003467	0.006973

Figure 2.3

BR	0.014417
BRKb	0.012761
CZR	0.004366
PPG	0.000092
PRU	0.007997

Figure 2.4

3 Efficient Portfolio Frontier

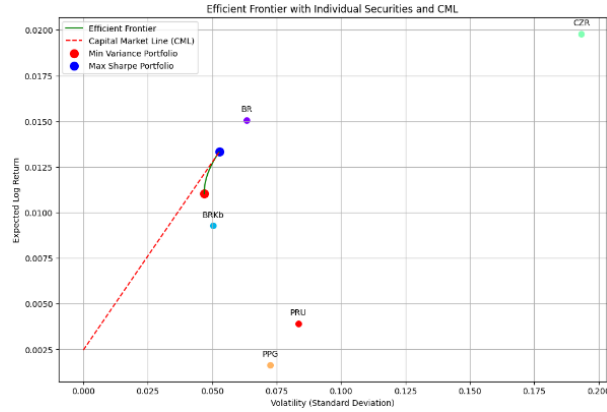


Figure 3.1

Given a basket of five risky titles and a 3% Risk-Free title, we obtain the Efficient Frontier represented in Figure 3.1. Below (Figure 3.2), the table shows the values of the portfolio with the lowest overall variance and the tangent portfolio, which is the portfolio that maximizes the Sharpe Ratio.

Portfolio	Weights	Volatility	Expected Return
Min Variance	[0.3, 0.7, 0.0, 0.0, 0.0]	0.0469	0.0110
Max Sharpe	[0.7, 0.3, 0.0, 0.0, 0.0]	0.0528	0.0133

Figure 3.2

As can be seen, the result from the optimization process shows a Tangent Portfolio that suggests investing exclusively in the first two stocks, with weights of 70% in Broadridge Financial Solutions and 30% in Berkshire Hathaway, respectively. This solution leads to a volatility of 5.28% and an Expected Monthly LogReturn of 0.0133, that is 17.306% annually in terms of simple return.

4 Efficient Portfolio Frontier with constraints

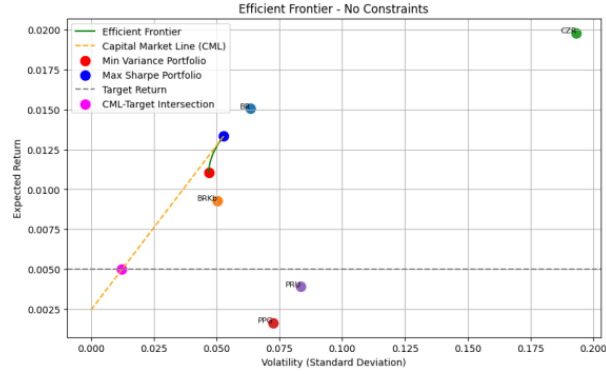


Figure 4.1

Given a Constraint that requires the sum of the weights of the first two titles to be 50%, it is possible to observe (Figure 4.2) an outperformance of the Tangent Portfolio over the target return of 0.0093 in terms of Expected Monthly LogReturn, that is 12.55% annually in terms of simple return.

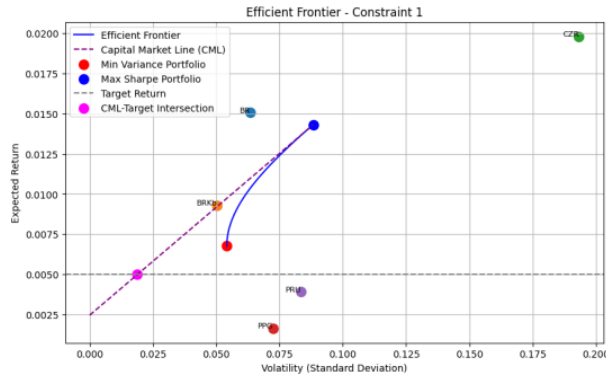


Figure 4.2

Given a Constraint that require at least 10% of capital to be invested in each title, it is possible to observe (Figure 4.3) an outperformance of the Tangent Portfolio over the target return of 0.0075 in terms of Expected Monthly LogReturn, that is 10.02% annually in terms of simple return.

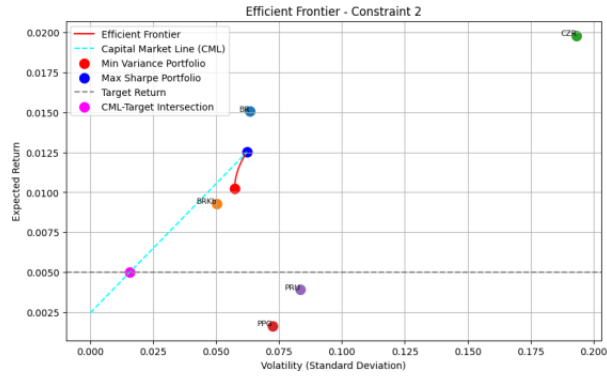


Figure 4.3

Setting a target return of 0.5%, the table (Figure 4.4) shows the weights of the portfolios that stand on the three different Capital Market Lines¹, composed by a combination of Tangent Portfolio (w_{Rtan}) and Risk-Free asset (w_{Rf}):

	Portfolio	Intersection Volatility	Intersection LogReturn	w_{Rtan}	w_{Rf}
0	No Constraints	0.0123	0.005	0.232939	0.767061
1	Constraint 1	0.0188	0.005	0.213260	0.786740
2	Constraint 2	0.0156	0.005	0.251506	0.748494

Figure 4.4

Is possible to notice that, to achieve the target return, it is required an exposure versus risk free asset of a range between 74 – 79% and versus Tangent Portfolio of a range between 21 - 26%.

¹With and without constraints

5 Capital Asset Pricing Model

At point 5 of the project has been developed a CAPM model to verify if the titles of the project were properly priced. To do this, first, we calculated the β of each title as

$$\beta_i = \frac{\text{cov}(R_i, R_m)}{\text{var}(R_m)}$$

where R_i is the vector of monthly total log return of title i and R_m is the vector of monthly total log return of S&P 500, used as a proxy of market return. After that, thanks to CAPM formula

$$\mathbb{E}[R_i] = R_f + \beta_i(R_m - R_f)$$

we calculated the right expected return of each title i according to the β_i . At the end, searching for alpha, we made the difference, for each asset, between the average total log return and the CAPM expected return discovering that some titles were overpriced and other underpriced.

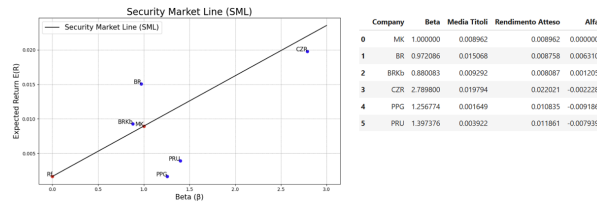


Figure 5.1

In the image above we can see the security market line and a panda's Data Frame where for each title are listed company name, beta, average total monthly log return, CAPM expected return and alpha. The security market line is the straight line with q equal to r_f , return of risk-free asset, and m equal to $R_m - R_f$ that put in relation the return of each asset to its respective beta. Only correct priced titles, according to CAPM model, stand on security market line. In the graph we can see that PRU, PPG and CRZ are overpriced titles because their averages returns are smaller than the relative CAPM returns so they have a negative alpha, and we should short sell these assets. Instead, BR and BRKb are underpriced titles because their average returns are bigger than the relative CAPM return so they have positive alpha, and we should buy these assets.

6 Black-Litterman model²

- **Views:**

- The stocks affected by the views are Berkshire Hathaway (BRKb) and Caesars Entertainment (CZR).
- For **BRKb**, the view consists of an expected extra return of 2%. Analyzing the balance sheet and the latest quarterly report, it is shown that the company has sold various positions, increasing its cash holdings to 300 billion dollars. This move may signal a strategy to take profits from previous investments and prepare for new acquisitions in undervalued companies, consistent with the management's investment philosophy. A hypothetical new acquisition announcement could justify this extra return.
- For **CZR**, a negative view has been assigned, with an expected extra return of -3.5%. This is based on financial statement analysis showing a problematic situation: a high level of debt and elevated interest expenses that outweigh the increase in earnings. The total debt stands at 25 billion dollars, with a debt-to-equity ratio of 6x.

- **Tau:**

- The sensitivity parameter τ of the model to the provided views was initially considered in the range $[0.01, 0.1]$.
- It was ultimately set to 0.1 to ensure a meaningful impact of the views on the portfolio weights.

- **Results:**

- The results obtained from the model align with expectations: the weights remain close to the market equilibrium weights, confirming the model's robustness.
- Only the stocks with views (BRKb and CZR) show significantly altered weights, which is consistent with the theoretical behavior of the Black-Litterman model.

²Question 6–7

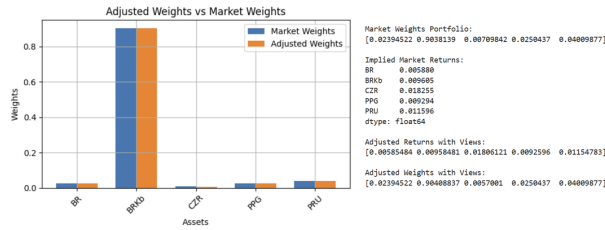


Figure 6.1

7 Views incorporation on Tracking Error Variance

The implementation of the model has been performed in the frame of a Black Litterman environment and adding the constrained optimization to minimize the Tracking Error Variance with the benchmark, which is the S&P500 index. Once the optimization weights process for minimizing the TEV is completed, it is possible to see (Figure 8.1) that the portfolio is principally exposed to Berkshire Hathaway, with a weight of about 83,69%. It is remarkable that the composition of the portfolio has remained consistent, keeping the weight's hierarchy unaltered, but providing a reduction of BRKB an orderly redistribution in the other weights, as shown by the outputs.

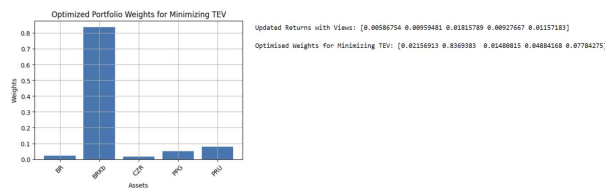


Figure 7.1