# Asset Management Project

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## Question 1

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 million in 2023.

Caesars Entertainments primary focus is on owning and operating casinos and resorts along, with entertainment facilities off all sort and generated a net income of 0.79 billion in 2023.

PPG Industries creates paints and coatings, for different industries like constructions 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.

## Question 2

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:

| | BR | BRKb | CZR | PPG | PRU |
|---|---|---|---|---|---|
| BR | 1.000000 | 0.441655 | 0.414259 | 0.523736 | 0.386517 |
| BRKb | 0.441655 | 1.000000 | 0.439054 | 0.624260 | 0.675080 |
| CZR | 0.414259 | 0.439054 | 1.000000 | 0.491739 | 0.596371 |
| PPG | 0.523736 | 0.624260 | 0.491739 | 1.000000 | 0.600151 |
| PRU | 0.386517 | 0.675080 | 0.596371 | 0.600151 | 1.000000 |

*Figure 2.1*

Variance - Covariance Matrix:

| | BR | BRKb | CZR | PPG | PRU |
|---|---|---|---|---|---|
| BR | 0.004017 | 0.001411 | 0.005074 | 0.002410 | 0.002046 |
| BRKb | 0.001411 | 0.002540 | 0.004277 | 0.002284 | 0.002841 |
| CZR | 0.005074 | 0.004277 | 0.037352 | 0.006900 | 0.009624 |
| PPG | 0.002410 | 0.002284 | 0.006900 | 0.005271 | 0.003638 |
| PRU | 0.002046 | 0.002841 | 0.009624 | 0.003638 | 0.006973 |

*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 lambda 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*

## Question 3

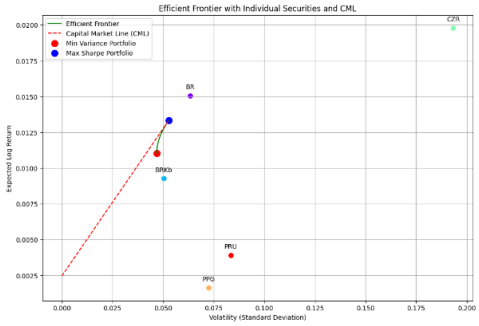



*Figure 3.1*

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.

## Question 4

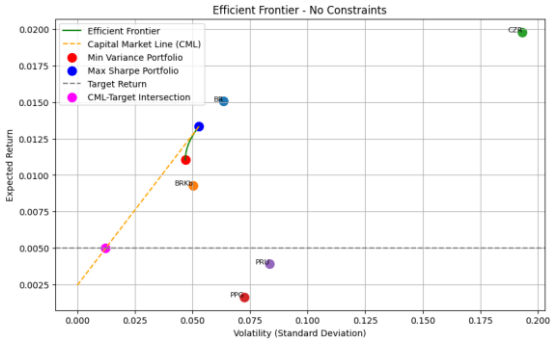



*Figure 4.1*

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.

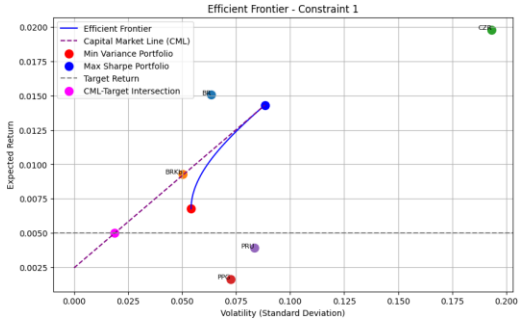



*Figure 4.2*

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.

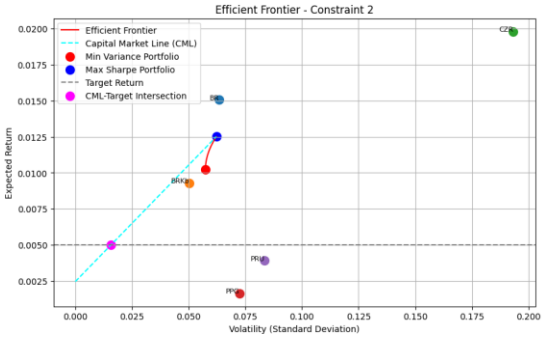



*Figure 4.3*

Setting a target return of **0.5%**, the table (*Figure 4.4*) shows the weights of the portfolios that stand on the three differents Capital Market Lines[1], composed by a combination of Tangent Portfolio (**wRtan**) and Risk-Free asset (**wRf**):

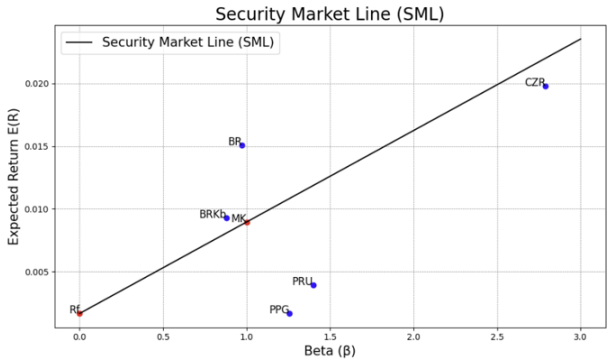
| | Portfolio | Intersection Volatility | Intersection LogReturn | wRtan | wRf |
|---|---|---|---|---|---|
| **0** | No Constraints | 0.0123 | 0.005 | 0.232939 | 0.767061 |
| **1** | Constraint 1 | 0.0188 | 0.005 | 0.213260 | 0.786740 |
| **2** | Constraint 2 | 0.0156 | 0.005 | 0.251506 | 0.748494 |

*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%**.

## Question 5

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 cov (Ri, Rm)/var (Rm), where Ri is the vector of monthly total log return of title i and Rm 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 $E[R_i] = Rf + \beta_i (Rm - Rf)$ we calculated the right expected return of each title i according to the $\beta_i$. 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.




| | Company | Beta | Media Titoli | Rendimento Atteso | Alfa |
|---|---|---|---|---|---|
| **0** | MK | 1.000000 | 0.008962 | 0.008962 | 0.000000 |
| **1** | BR | 0.972086 | 0.015068 | 0.008758 | 0.006310 |
| **2** | BRKb | 0.880083 | 0.009292 | 0.008087 | 0.001205 |
| **3** | CZR | 2.789800 | 0.019794 | 0.022021 | -0.002228 |
| **4** | PPG | 1.256774 | 0.001649 | 0.010835 | -0.009186 |
| **5** | PRU | 1.397376 | 0.003922 | 0.011861 | -0.007939 |

*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

[1] With and without constrains

line is the straight line with q equal to rf, return of risk-free asset, and m equal to Rm-Rf 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.

## Question 6 - 7

To provide the implementation of the Black Litterman model it has been decided to define the following inputs:

**Views**

The stocks affected by the views are Berkshire Hathaway (BRKb) and Caesars Entertainment (CZR):

As for BRKb, the view consists of an expected extra return of 2%. Analyzing the balance sheet and the last quarterly release of the company, it is shown that the company has sold various position, increasing its cash position to 300 billion; this can be seen as a strategy aimed to take the profits of the previous investments and preparing new acquisitions in undervalued companies, in line with the investing philosophy of the management. The hypothetic new acquisition announcement could provide an extra return to the stock.

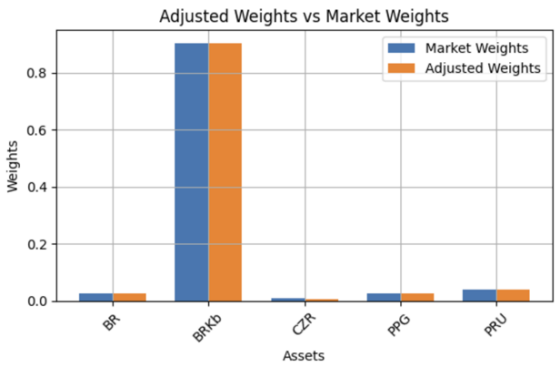
On the other hand, for CZR has been decided to provide a negative view, with a negative extra return of 3.5%. The motivation of this choice is that the financial statement analysis provides a problematic view of the company's health. It shows a high level of debt and a consequently high interest expense, which overcompensate the increase in the earnings shown. The total debt is 25 billion, with a debt-to-equity ratio of 6x.

**Tau**

The parameter of sensitivity of the model to the provided views has been firstly chosen in the range of [0.01, 0.1], and then it has been defined to 0.1, because the intention is to provide a sensible effect on the portfolio weights.

**Results**

The results obtained by the model are in line with expectation: the weights are quite like the market equilibrium weights, showing the robustness of the model; moreover, the only weights affected by different weights are the ones with the view, in line with what is expected:



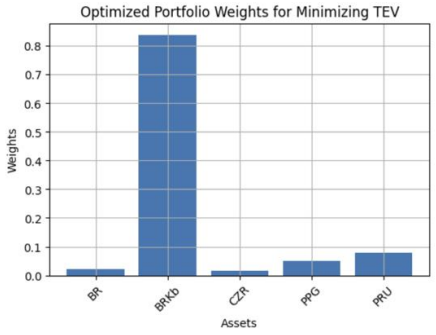

```
Market Weights Portfolio:
[0.02394522 0.9038139  0.00709842 0.0250437  0.04009877]

Implied Market Returns:
BR      0.005880
BRKb    0.009605
CZR     0.018255
PPG     0.009294
PRU     0.011596
dtype: float64

Adjusted Returns with Views:
[0.00585484 0.00958481 0.01806121 0.0092596  0.01154783]

Adjusted Weights with Views:
[0.02394522 0.90408837 0.0057001  0.0250437  0.04009877]
```

*Figure 6.1*

## Question 8

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.




```
Updated Returns with Views: [0.00586754 0.00959481 0.01815789 0.00927667 0.01157183]

Optimised Weights for Minimizing TEV: [0.02156913 0.8369383  0.01480815 0.04884168 0.07784275]
```

*Figure 8.1*