Quantitative Asset and Risk Management

Project #1: Asset Allocation with a Carbon Objective

Due Tuesday April 18, 2023, at the beginning of the class

The goal of this project is to implement the quantitative asset management concepts seen in class. The first part of the project consists in building a portfolio in the framework given to you (e.g., mean-variance criterion, minimum-variance criterion, risk budgeting, etc.). The second part focuses on the the sustainable dimension of the portfolio. You are given a certain degree of freedom within the given framework. You have to define the methodology that seems the most appropriate to you.

You must submit a PDF-report with the details of your methodology and an analysis of the results, and a folder containing your codes files such that we can replicate your results by running the code. Each group will present their results in class. You are graded based on your report and your code.

You must use the list of companies assigned to your group. Projects provided after this deadline will not be considered.

Data

On Moodle, you are given an csv-file (yourgroup.csv) that contains some basic information regarding a list of firms:

- ISIN code
- Name of the firm
- Country / region
- Sector

With the ISIN code, you have to extract from Datastream (Refinitiv) at CEDIF (Internef) a complementary database that contains

- Market capitalization (daily) (X(MV)~U$)
- Total return index (price index, including dividend payments) (daily) (X(RI#T)~U$)
- Revenues (monthly) (X(WC01001)~U$)
- CO_2 emissions (monthly) (ENERDP123)

Additional information:

- Collect the data from 1999 to 2022.
- All data must be expressed in US dollar, when relevant (hence the expression "$\sim$U$" at the end of the mnemonics).
- The first part of the project (asset management) can be done using monthly data. For data available at daily frequency (market cap and prices), use the data from the last day of the month. Revenues and CO_2 are usually updated annually but not necessarily in January, so using monthly data is more accurate.
- The second project (related to risk management) will be done using the same data but at the daily frequency for stock prices.

1 Standard Asset allocation

1.1 Describe the characteristics of the stocks that you have been assigned to. As there are many stocks, find a smart way (table, chart, aggregated data, etc.) to illustrate these properties.

1.2 Build the efficient frontier using the sample mean and the sample covariance matrix estimated over the full sample. Report clearly your methodology.

1.3 Use the resampling approach to determine the optimal weights of the in-sample portfolio. Compare the efficient frontier with that obtained in point 1.2.

1.4 Pick the portfolio that corresponds to the strategy assigned to your group. You may need to use an optimizer to obtain these weights. Compute the characteristics of this in-sample portfolio (denoted "P_{is}") over the sample: annualized average return, annualized volatility, minimum, maximum, max drawdown, Value-at-Risk (VaR) and Expected Shortfall (ES). Compare these properties to those of the value-weighted and equal-weighted portfolios.

1.5 Now, proceed in the same way but out of sample. Use the first 6 years of monthly returns to compute the vector of expected and the covariance matrix. The allocation is determined at the end of month t for month $t+1$. Compute the optimal allocation of your portfolio and its ex-post performance. Then, roll the window by one month and iterate until the end of the sample, so that your portfolio is rebalanced each month from Jan. 2005 to Dec. 2022. Compute the characteristics of this out-of-sample portfolio (denoted "P_{oos}") over the sample. Compare these properties to those of the value-weighted and equal-weighted portfolios.

1.6 Restrict the optimal weights to be positive (portfolio denoted "$P_{oos}^{(+)}$"), if relevant. You need to use an optimizer to obtain these new weights. Compute the characteristics of this out-of-sample portfolio over the sample and compare these properties to those of the portfolio P_{oos} of point 1.5.

2 Asset Allocation with a Carbon Objective

We now add a layer in the portfolio construction by taking CO_2 emission into account.

2.1 Start by constructing the carbon intensity of all firms in your investment set. It is computed in tons of CO_2 equivalent per million U.S. dollars of revenue. Consider the last year of your sample with sufficient carbon data (2021) and reduce the set of stocks to those with a carbon intensity. Comment the distribution of the carbon intensity across firms. Rerun point 1.6 (optimal long-only portfolio) for the set of stocks with a carbon intensity (denoted "$P_{oos}^{(+b)}$").

2.2 We compute the carbon footprint of a portfolio as the amount of annual carbon emissions that can be allocated to the investor per million U.S. dollars invested in the portfolio:

$$CF_t^{(p)} = \frac{1}{V_t} \sum_{i=1}^{N_t} o_{i,t} E_{i,t}$$

where $o_{i,t} = V_{i,t}/Cap_{i,t}$ measures the fraction of the equity of the firm owned by the portfolio, with $V_{i,t}$ the dollar value invested in firm i, $Cap_{i,t}$ the market capitalization of the firm and $V_t = \sum_{i=1}^{N_t} V_{i,t}$ the dollar value of the portfolio. N_t denotes the number of firms in the portfolio. Compute the carbon footprint of $P_{oos}^{(+b)}$ assuming a starting wealth equal to 1 million U.S. dollars. We want to construct an optimal long-only portfolio with a carbon footprint 75% below the carbon footprint of the optimal long-only portfolio $P_{oos}^{(+b)}$ determined in point 2.1. For the set of stocks to those with a carbon intensity, compute the optimal weights of the long-only portfolio with a carbon footprint lower or equal to $0.75 \times$ the carbon footprint of $P_{oos}^{(+b)}$. We denote this portfolio "$P_{oos}^{(+b)}(0.75)$".

2.3 Comment on the trade-off between the financial performance of the portfolio and the reduction in its carbon footprint.