APS 1022 Computational Project 2021

Instructions: You may do this project in groups of up to two. Use MATLAB and its optimization routines. Due June 11th, 2021 by 5PM.

Introduction

The purpose of this project is to implement and compare several different financial optimization models. Portfolios will be generated using these models and these portfolios will be tested out-of-sample. The optimization models that you will implement are the following.

(1) Mean-variance optimization (MVO)

Use the following version of MVO:

$$\min_x \mu^T x - \lambda x^T Q x$$
$$\text{subject to } e^T x = 1$$

where $\mu \in R^n$ is the vector of expected returns, $Q \in R^{n \times n}$ is the covariance matrix, and $e \in R^n$ is a vector of n ones. Short selling is allowed. $\lambda > 0$ is a risk aversion parameter.

(2) Robust mean-variance optimization

You can use box or ellipsoidal uncertainty sets. See slide 16 in the Robust MVO slides posted to see how you should formulate the robust model.

(3) Risk Parity optimization with no short selling.

Use the risk parity model that is easiest to use (the version that uses theta as a variable).

Asset Universe

Our investment universe consists of 20 stocks (n=20) all of which are constituents of the S&P 500. The stock symbols are

F (Ford Motor Co.), CAT (Catepillar Inc.), $DIS, MCD, KO, PEP, WMT, C, WFC, JPM$,$AAPL, IBM, PFE, JNJ, XOM, MRO, ED, T, VZ, and\ NEM$.

Parameter Estimation

Using monthly (last trading day of each month) adjusted closing prices for each stock from 30-Dec-2004 to 30-Sep-2008 compute the sample mean and sample variance for each stock. Also, compute sample covariances. Now consider the portfolios generated from MVO, robust MVO, and risk parity by using the estimated parameters. Consider a fourth portfolio of the 20 stocks where the weights are based on market capitalizations (here assume the 20 stocks is the market).

sample mean ->

(a) Take each of the four portfolios (weights) generated by using the 4 different methods and using the realized return for each stock for the month of Oct of 2008 compute the major portfolio quantities for each portfolio for **just** the month of Oct. 2008 i.e. compute (1) portfolio return (2) portfolio variance

and standard deviation and (3) Sharpe ratio. Discuss the results i.e. explain why you think a portfolio did better than another on these portfolio dimensions e.g. why was the Sharpe ratio of a portfolio from a particular strategy better than a portfolio generated by a different strategy? and which portfolio did best (worst) on return and why?

Note that for MVO and robust MVO that you have to select a risk aversion value for λ. I would suggest to set this value to the quantity that Idzorek (see Black-Litterman paper and class slides) suggests (in this case the market (mkt) is the group of 20 stocks listed above and you would need to estimate its mean and variance and you need to use a quantity for the risk-free rate.). Be sure to state how you came up with these quantities in your report. Also, for robust MVO do cases for confidence levels of 90% and 95%.

(b) Repeat (a) but use the realized returns for Nov. of 2008 instead of Oct. 2008.

(c) Using the estimated parameters and the realized return for Oct. 2008 as true returns for the assets generate (1) the estimated MVO frontier (2) true MVO frontier (3) the actual MVO frontier (4) actual robust frontier and (5) estimated robust MVO frontier. Plot them all on the same graph. Note that you must use a sufficient number of different risk aversion parameters to generate frontiers. For robust MVO do cases for confidence levels of 90% and 95%.

5 curves * 3 plots

Discuss the results. See the slides on robust MVO.

Deliverables

Prepare a formal project report. It should be well written and concise. The report should address the requirements above in written prose and not in a fragmented manner. Use nice visual aids whenver you can as well as summarizing estimated parameters and computational results in nice tabular form. It is also important to discuss your results in a well written manner and be sure to NOT just dump numbers in the report. Describe advantages and disadvantages of the four differing methods. Have a script that executes your models and that generates the efficient frontiers so a TA can verify the output of your report. Give clear instructions on how to run your code AND it must be simple and direct as possible. The code must be EASILY run without ANY modification by the TA.

You need to send your actual MATLAB files including the estimated parameters and your report (word or pdf) in a zip file. Send to me via e-mail rkwon@mie.utoronto.ca. Name your zip file *yourname_APS1022_project1.zip* and you must write as the subject of your e-mail **APS 1022 project 2021.**

You do NOT need to hand in a hardcopy of your report.