School of Electronics and Computer Science
University of Southampton

COMP6212 Computational Finance 2016/17, Assignment 1 (of 4) 30%

Issue	20 February 2017
Due	8 March 2017

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1. Consider three securities whose expected returns are

$$\mathbf{m} = \begin{bmatrix} 0.10 & 0.20 & 0.15 \end{bmatrix}^t,$$

and their corresponding covariances are

$$C = \begin{bmatrix} 0.005 & -0.010 & 0.004 \\ -0.010 & 0.040 & -0.002 \\ 0.004 & -0.002 & 0.023 \end{bmatrix}$$

(This example is taken from MATLAB's Finance Toolbox)

   (a) Generate 100 random portfolios and plot a scatter diagram in the $E - V$ space as shown in Fig. 1 of [1].

   (b) Use MATLAB's `frontcon` function to draw the efficient portfolio frontier for this three-asset model, and for the three two-asset portfolios, taking the assets pair-wise. Draw the graphs and scatter of points using the same scale and briefly comment on what you observe.

   (c) Briefly explain "in your own words" why linear programming (`linprog`) is used in the `NaiveMV` function for computing the efficient frontier in [2], Fig. 6.11, page 384. Note this function was discussed in class.

   (d) Set up the `CVX` Convex Programming toolbox and familiarize yourself with it. Work through one or two simple examples given in the documentation.
   Replace the two optimization steps in the `NaiveMV` function (*i.e.* calls to `linprog` and `quadprog` by `CVX` and show that similar results (or identical results?) are produced.

2. Obtain daily `FTSE 100` data for the past three years and data for the prices of 30 companies in the `FTSE` index. `Yahoo Finance` may be a convenient source.

   - Select three stocks at random and estimate the expected returns and covariances from the first half of the time series. Select assets for which approximately equal lengths of data is available and use a simple method to impute any missing values in them.
   - Using the above estimates design an efficient portfolio.
   - Would the portfolio have performed better than the simple $\frac{1}{N}$ portfolio during the remainder of the period for which you have data (see [3])?

3. Using the above data, implement and compare two strategies for *Index Tracking*: **(a)** a greedy forward selection algorithm that selects about a fifth of the available stocks; and **(b)** sparse index tracking portfolio using l_1 regularization as discussed in [4]. Tune the regularization parameter so that the number of stocks selected by the regularization scheme is similar to the number selected in method (a).

4. Lobo *et al.* [5] discuss how transaction costs may be included in optimizing adjustments to a portfolio. Study how they impose various constraints, and explain "in your own words" aspects of the optimization problem formulated in the example of Section 1.6 of this paper: what the objective function is, what the constraints are and how you might extend the work you have done so far to implement this. What is needed is an insightful discussion; you need not actually implement this.

Marking Scheme

Efficient Mean-Variance frontier	10%
Evaluation of performance	5%
Greedy and sparse index tracking	10%
Discussion of Lobo *et al.*	5%

In general 6/10 and 3/5 of marks in any catregory will be awarded for correctly doing what you are instructed to do. Additional marks are gained by "going the extra mile", *i.e.* for showing initiative of reading slightly outside what was taught, demonstrating clear understanding, presenting the work high standards etc.

Report

Write a report of no more than eight pages describing the work you have done, answering any questions above. Pay attention to technical writing to high standards. Do not cut and paste formulae or figures from other sources; you must typeset them or draw them yourself. Neat hand-written sketches and formulae may be included if they are your own work. Figures and tables should have informative captions.

Note this assignment is worth 30% of the assessment for the module. It is recommended you spend 30 hours on this assignment.

References

[1] H. Markowitz, "Portfolio selection," *The Journal of Finance*, vol. 7, no. 1, pp. 77 – 91, 1952.

[2] P. Brandimarte, *Numerical Methods in Finance and Economics*. Wiley, 2006.

[3] V. DeMiguel, L. Garlappi, and R. Uppal, "Optimal versus naive diversification: How inefficient is the 1/n portfolio strategy?" *The Review of Financial Studies*, vol. 22, no. 5, pp. 1915 – 1953, 2009.

[4] J. Brodie, I. Daubechies, C. De Mol, D. Giannone, and I. Loris, "Sparse and stable Markowitz portfolios," *PNAS*, vol. 106, no. 30, pp. 12 267 – 12 272, 2009.

[5] M. Lobo, M. Fazel, and S. Boyd, "Portfolio optimization with linear and fixed transaction costs," *Annals of Operations Research*, vol. 152, no. 1, pp. 341–365, 2007.

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