15.433: Financial Markets
Fall 2022

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ASSIGNMENT 6

Due: December 1, 2022 by 11:59 pm ET.

Instructions: This assignment can be completed in groups of up to four students. Only one assignment needs to be submitted per group. Assignments should be submitted electronically via the "Assignment" portal on Canvas. Remember to attach a printout of any code you write the end of the assignment.

The objective of this exercise is to practice using the Black-Litterman (1992) model. There are two components to Black-Litterman. The first is to use an "equilibrium" (or consensus) risk premium estimate as a starting point. The second is to add your own view and form a new risk premium estimate. The lecture notes "Black-Litterman Example" uploaded to Canvas discuss this procedure in detail.

The data used for this exercise are identical to those used by He and Litterman in their paper "The Intuition Behind Black-Litterman Model Portfolios" (1999). (For your reference, the paper is uploaded to Canvas as "GS_The_intuition_behind.pdf". For your convenience, the data are uploaded as the file "he_litterman_data.csv" in the "Assignment 6" folder on Canvas.)

1. Derivation of equilibrium risk premia:
    a. Using a software package of your choice, replicate the third column, "Equilibrium Expected Returns," reported in Table 1 of Appendix A of He-Litterman (1999). Specifically, solve the mean-variance optimization problem of an average (or "representative") investor,
    $$\max_{w} w'\mu - 0.5\delta w'\Sigma w,$$
    imposing the condition that, if everyone does the same calculation and has the same risk aversion, then the resulting portfolio weights must equal the market-cap weights.
    b. An alternative way to derive the equilibrium risk premia is to use the CAPM from the perspective of a U.S. investor. U.S. equity market data are available for a long history, so the U.S. equity risk premium could be a commonly agreed-upon starting point. Using the covariance matrix provided in Table 2 of "he_litterman_data.csv", calculate the betas of the stock indices of the other six countries with respect to the U.S. equity market, and use the CAPM to derive the expected equity returns for the six countries. For this exercise, you may just impose a reasonable estimate of the U.S. equity risk premium, which you should already know from our earlier class discussions or from 15.415/401. What are the CAPM-implied risk premia for the other six countries?

2. Add a view and derive new estimates of the risk premia, covariance matrix, and portfolio weights:
    a. Formulate a view (any view you want) and express it in the matrix form $P'R = Q + \epsilon$. You need to specify matrices P and Q, as well as the variance matrix Ω of ϵ. Comment on the confidence or strength of your view, given your choice of Ω.
    b. Specify the τ parameter, where $\tau\Sigma$ is the covariance matrix of expected returns R.
    c. Based on these parameters, calculate the Black-Litterman-implied risk premia μ_{BL} and the new portfolio weights. You may use the original covariance matrix of the expected returns or the updated one.
3. Vary your inputs of τ and Ω in the calculation. How sensitive are your results to these inputs?