Popular Science Summary

Covariance Matrix Regularization for Portfolio Selection: Achieving Desired Risk

Manu Upadhyaya
Manu.Upadhyaya.42@gmail.com

Investors allocate capital into various financial instruments with the expectation of a future financial return. Inherit in each investment is a trade-off between risk and return. In the early 1950s, the economist and Nobel Laureate Harry Markowitz formalized the risk and return trade-off when investing in multiple financial instruments, that is, in portfolio construction. In fact, Markowitz portfolio selection, also called modern portfolio theory, remains a cornerstone of finance, both for researchers and asset managers.

The application of Markowitz portfolio selection crucially relies on two items: (i) the estimation of the expected returns over some future time period for the relevant financial instruments, and (ii) the estimation of the variances and covariances between these returns. Variance is a measure of how far a value is spread out from its expected or average value while the covariance is a measure of joint variability of two values. In particular, the variances and covariances are structured in tabular form, called the covariance matrix. Thus, investors utilizing the Markowitz portfolio selection framework need to estimate the expected returns and the covariance matrix from historical data. This thesis deals with the latter item, from the perspective of an asset manager.

Typical and well-known estimates of the covariance matrix found in the statistics literature are typically ill-suited for portfolio selection and yield poor portfolio performance. However, a number of so-called covariance matrix regularization methods has been suggested in the literature and lead to improved portfolio performance. Covariance matrix regularization is done by in a systematical manner altering the values in standard covariance matrix estimates. Moreover, most asset managers promise clients an annual risk target, where risk is measured by realized standard deviation of portfolio returns. Standard deviation is the square root of variance.

This thesis presents a data-driven method for covariance matrix regularization with the aim to achieve a realized portfolio risk as close to some selected risk target. Critically, the data-driven method is a framework centered around a so-called loss function. A novel risk targeting loss function is constructed and used. Using historical price data from multiple futures exchanges, the data-driven method outperforms widely used and cutting edge covariance matrix regularization methods found in the literature. Thus, the thesis provides asset managers using the Markowitz portfolio selection framework a new tool to better achieve desired risk.