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# Portfolio optimization in the Black-Litterman framework for general distributions

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**Abstract:** It is well known that in a classical Markowitz portfolio optimization problem optimal weights are quite different from being optimal in real-life investment. Black and Litterman offered an improvement wherein investors' views on expected returns are incorporated into the optimization. An essential drawback of the Black-Litterman model is its limitation to normal distributions. That limitation was relaxed by a number of authors in subsequent papers (Meucci, Xiao&Valdez). The existing extensions to the Black-Litterman model are either limited to elliptic distributions or ignore an essential ingredient of the model – the existence of market equilibrium.

In the talk, we present an extension of the Black-Litterman model to general (empirical) distributions. The application of the Black-Litterman methodology consists of three steps: (i) computation of an equilibrium distribution of returns, (ii) modification of this distribution according to investors' predictions about future returns and, (iii) based on this modified distribution, computation of an optimal portfolio. Generalization of this methodology to non-Gaussian distributions requires modifications to all three steps. We describe an efficient numerical algorithms for the inverse optimization problem that extracts in a stable way statistical information from historical data. We develop a quantitative model for stating investors' views and blending them consistently with the market information – in this construction we follow an analogy with the original Black-Litterman approach where the distribution of forecasts inherits a general shape from the distribution of market returns. Finally, we perform portfolio optimization with the obtained distribution of asset returns.