An Essay on How to Implement Views in the Black–Litterman Formula

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1 The formulas

Let's first introduce how we can encode the views in the Black–Litterman model:

$$P\,\mu \;=\; Q \;+\; \varepsilon, \qquad \varepsilon \sim \mathcal{N}(0,\;\Omega)\,.$$

where:

- $\mathbf{q}$ is the vector of view-implied excess returns,
- $\mathbf{P}$ is the pick matrix (asset weights per view),
- $\boldsymbol{\pi}$ is the (unknown) equilibrium excess return vector,
- $\boldsymbol{\varepsilon}$ is a normally distributed error term, and
- $\boldsymbol{\Omega}$ is the symmetric covariance matrix of the view errors.

With $\boldsymbol{\Omega}$ equal to:

$$\boldsymbol{\Omega} = \left(\frac{1}{c} - 1\right) \mathbf{P}\boldsymbol{\Sigma}\mathbf{P}^T$$

where:

- $\boldsymbol{\Sigma}$ is the covariance matrix to be determined,
- and c is a constant that we need to determine.

Le calcul de la matrice Q va s'effectuer de plusieurs manières :

Q calculé par l'esperance du spread sur 1 ans avec 12 recompo de portefeuille lookback 3 mois et 1 mois de hold.

I) The Black and Litterman Model, a short introduction

II) Computing the model

We will have two types of view to compute : market implied returns and investissors views.

For the market view, will strat from this equation given by Markowitz optimization framework :

$$U = w^T\hat{\mu} - \frac{\lambda}{2}w^T\Sigma w$$

With :
U: The quadratic utility function used to measure portfolio performance
w: The market capitalisation weight of assets
$\hat{\mu}$: The implied excess equilibrium return vector
λ: The risk aversion parameter
Σ: The covariance matrix of excess returns on assets.

We want to maximise the Utility function (equation 1) to have the implied return given at a λ state. We will define later on how to define λ.

$$\max_w U = w^T\hat{\mu} - \frac{\lambda}{2}w^T\Sigma w$$

Using basic derivation skill we can find :

$$\hat{\mu} = \lambda\Sigma w$$

We can estimate λ by

$$\lambda = \frac{(r - r_f)}{\sigma^2}$$

r: Total return on the market portfolio, $r = w^T P_e + r_f$
r_f: Risk free rate
σ^2: Variance of the market portfolio
I will take $\lambda = 0.5$ according to literature.

$$\mu = \hat{\mu} + \varepsilon \quad \text{with} \quad \varepsilon \sim \mathcal{N}(0, \tau\Sigma).$$

2 We now have the market implied return, we can compute the investors views

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Black and Litterman specify expected returns as follows: