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Using Bayesian Mixed Estimation Methods to Construct Enhanced Index Strategies

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Outline

- What is an Enhanced Index fund?
- Using Enhanced Index funds to avoid implementation shortfall
- Combining portfolio forecasts to construct a consistent view
- Alternative derivations and interpretations of Mixed Estimation
- Recent advances in the application of Mixed Estimation

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What is an Enhanced Index fund?

- There is no clear agreement on what constitutes an "Enhanced Index" strategy, the term is also applied to "alpha transport" strategies and to techniques which seek to enhance returns on passive index tracking strategies
- Here, we define an enhanced index fund to be a mean variance efficient equity fund designed using an active quantitative strategy to deliver superior performance with low ex-ante tracking error:
- tightly benchmarked to a recognised index thereby retaining much of the risk characteristics of a passive fund
- only mildly tilted so efficiency is unlikely to be affected by long-only constraints
- portfolio trading potentially ensures tight control of transaction and implementation costs

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Avoiding implementation shortfall

- The challenge for active management is to translate skill and insight whether at the stock selection or asset allocation level into efficient portfolios
- It is tempting to build optimal portfolios at the asset allocation level - where greater control can be placed on the process - yet we still have to translate the resulting country and industry weights into efficient portfolios of stocks
- Macro level forecasts are often only used to guide manual portfolio construction - the resulting stock level portfolios frequently have risk characteristics that are very different from the ‘portfolios’ at the asset level
- **Yet it is even harder to convert estimates of alpha at the stock level into suitable inputs for use in optimisation**

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Why not combine passive and active?

- A possible strategy is to combine both approaches in a mixed fund, for example 80% in an index tracking fund and 20% in an actively managed fund
- However, such an arbitrary combination of portfolios may be cost efficient, but is unlikely to be mean-variance efficient
- Furthermore, the active fund will have to take large positions in order to compensate for the dead-weight cost of the index portfolio
- The presence of long-only constraints will typically result in a large cap bias impacting performance Grinold & Kahn (2000)
- The active fund also needs to identify stocks that generate significant outperformance as opposed to those that simply give a better return on average

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Why is MV optimisation not used more widely?

- The basic idea of portfolio optimisation is intuitively very appealing: we maximise an investors objective function subject to a set of constraints - some like the budget constraint reflecting economic criteria whilst others, no short holdings for example, are arguably imposed to reduce risk

- That such techniques are not more widely used by practitioners has been referred to as the “optimisation enigma” Michaud (2001). Yet, as both computing power and our understanding of the true statistical basis of the problem have increased there has been a recent growth of interest in portfolio optimisation

- The main objections to the use of optimisation relate both to the difficulty of adequately representing an investors utility function, the difficulty of estimating all the required inputs, especially the alphas and the resulting instability of the process

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Estimating conditional Alpha's

- Producing estimates of alpha at the stock level consistent with the risk model used for optimisation is a non-trivial problem and the source of much of the instability in the optimal solution
- Badly conditioned alphas lead to excessive trading, unstable solutions and require the solution to be heavily constrained to get an acceptable "investment grade" portfolio
- The standard approach where the alphas are rescaled to allow for information content and residual volatility offers only a partial solution
- Our preferred solution is to use a Bayesian Mixed Estimation procedure where the distribution of the forecast alphas is 'mixed' with the distribution of the data to produce a robust estimate of the conditional alpha - see Scowcroft and Sefton (2003)

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Combining portfolio forecasts

- It is our contention that it is an easier task to forecast the mean return for a group of stocks that share a common characteristic than it is to forecast individual stock returns
- Such forecasts are best represented as the return to a portfolio, where the portfolio could be for example an industry, a geographical region or an equity style
- Bayesian Mixed Estimation provides a quantitatively rigorous way to combine multiple portfolio forecasts and properly account for the varying degree of confidence between the forecasts
- As we shall see, it can also be extended to incorporate stock specific forecasts and therefore potentially provides a framework to reconcile both top down and bottom up forecasts as well as subjective and quantitative forecasts

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Mixed estimation - the data

- We model stock returns as the sum of the long-run equilibrium return vector μ and a vector of stochastic returns ε_t with zero mean and covariance matrix Σ the distribution of the data is therefore given by

$$\mathbf{r}_t \sim N\left(\boldsymbol{\mu}, \boldsymbol{\Sigma}\right)$$

- If markets are efficient then the expected return vector would equal μ since $E(\varepsilon_t)=\mathbf{0}$ however, there are several reasons why this may not be the case in practice

- Firstly, we may have some insight or information which is not yet in the public domain and therefore not reflected in the current price vector

- Secondly, there is an increasing body of evidence, summarised in Cochrane (1999a), that prices are to some extent forecastable

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Mixed estimation - our forecasts

- For a benchmark of *n* stocks, we model our forecasts as the expected return to a set of *p* portfolios represented by the $p \times n$ matrix **P**

- Our forecasts are assumed to be distributed around the final realised vector of returns with a stochastic error term ν_t

$$\mathbf{g}_t = \mathbf{P}\left(\mathbf{r}_t - \boldsymbol{\mu}\right) + \mathbf{v}_t \qquad \text{where} \qquad \mathbf{v}_t \sim N\left(\mathbf{0}, \boldsymbol{\Omega}\right)$$

- The forecasts are expressed relative to the benchmark return and are assumed to be unbiased

- In order to compute the conditional distribution of return we utilise a straightforward application of Bayes' theorem

$$\Pr\left(\mathbf{r}_t \middle| \mathbf{g}_t\right) \propto \Pr\left(\mathbf{g}_t \middle| \mathbf{r}_t\right) \Pr\left(\mathbf{r}_t\right)$$

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The Theil-Goldberger formula

- Substituting into Bayes' theorem the assumed distributions of the data and our prior gives the posterior distribution

$$\mathbf{r}_t \big| \mathbf{g}_t \sim N\left(\boldsymbol{\mu} + \left(\boldsymbol{\Sigma}^{-1} + \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{P}\right)^{-1} \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{g}_t, \left(\boldsymbol{\Sigma}^{-1} + \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{P}\right)\right)$$

- The expected relative return or alpha is therefore given by

$$E\left(\mathbf{r}_t \big| \mathbf{g}_t\right) - \boldsymbol{\mu} = \boldsymbol{\alpha}_t = \left(\boldsymbol{\Sigma}^{-1} + \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{P}\right)^{-1} \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{g}_t$$

- Note that our forecast alpha now depends only on our prior distribution for the *p* portfolios and the covariance matrix, not μ

- It is more convenient to compute the alphas using

$$\boldsymbol{\alpha}_t = \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1} \mathbf{g}_t$$

- See Appendix A for the derivation

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A ranking example

- Suppose that we have used a valuation model to group stocks into quintiles, the matrices will look like:

$$\mathbf{P} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1N} \\ w_{21} & w_{22} & \cdots & w_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ w_{51} & w_{52} & \cdots & w_{5N} \end{bmatrix} \quad \mathbf{g} = \begin{bmatrix} g_1 \\ g_2 \\ \vdots \\ g_5 \end{bmatrix} \quad \mathbf{\Omega} = \begin{bmatrix} \omega_{11}^2 & 0 & \cdots & 0 \\ 0 & \omega_{22}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \omega_{55}^2 \end{bmatrix}$$

- Where the weights for the five ranking portfolios are expressed relative to the benchmark - hence the sum across each row will equal zero

- **It is easier to produce forecasts for baskets of stocks that are expected to outperform on average than it is to identify individual stocks with strong outperformance**

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An asset allocation example

- Scowcroft and Sefton (2003) section 4.4, provides a worked example for a set of forecasts for ten global industries and seven main economic regions

- The optimal solutions were computed using both a traditional asset allocation model and a stock level optimisation using alphas generated with the Theil-Goldberger formula - the aggregate solution weights were in close agreement

- A further set of optimisations was done using a subset of four key forecasts and again the results were broadly very similar - it is not necessary to have a comprehensive set of consistent forecasts

- Only when stock level constraints were introduced did the industry and regional weights begin to diverge reflecting the inherent non-linearities of the integer restrictions

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A comparison with simple scaling rules

- A forecasting rule of thumb frequently used to scale alphas in practice is that proposed by Grinold and Kahn (2000), namely

$$E\left(r_t \middle| g_t\right) = std\left(r_t\right) * \rho\left(r_t, g_t\right) \frac{g_t}{std\left(g_t\right)}$$

$$= Volatility * IC * Score$$

- In the case of a **single** asset this is equivalent to the Theil formula However, in the case of multiple assets and forecasts the rule of thumb is only approximate, Bulsing and Sefton (2002)

- There is also much confusion over whether the IC relates to the forecast time series or the underlying cross sectional stock selection model, Qian and Hua (2002)

- In our view the forecast accuracy matrix Ω is something that analysts should have a greater intuitive feel for than IC

Calculating Ω from a time series IC

- For a single portfolio forecast g_t Bulsing and Sefton (2002, 2003) show that the ***time series*** IC is given by:

$$IC_i = \text{cov}\left(g_{it}, \boldsymbol{Pr}_t\right) / \text{std}\left(g_{it}\right)\text{std}\left(\boldsymbol{Pr}_t\right) = \frac{\boldsymbol{P\Sigma P'}}{\left(\boldsymbol{P\Sigma P'} + \omega_i\right)^{1/2}\left(\boldsymbol{P\Sigma P'}\right)^{1/2}}$$

- The required input ω_i is therefore given by

$$\omega_i = \left(\frac{1}{IC^2} - 1\right)\boldsymbol{P\Sigma P'}$$

$$\omega_i^{1/2} = \sigma_{iP}\left(\frac{1}{r^2} - 1\right)^{1/2} = \sigma_{iP}\left(\frac{\text{residual sum of squares}}{\text{explained sum of squares}}\right)^{1/2}$$

where σ_{iP} denotes the "tracking error" of the i'th portfolio.

- **Forecast Error Volatility = Tracking Error X Predictability**

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An alternative formulation

- Using the same assumptions as before for the forecasts and data we can write the equations directly as a joint normal

$$\begin{bmatrix} \mathbf{r}_t \\ \mathbf{g}_t \end{bmatrix} \sim N\left(\begin{bmatrix} \boldsymbol{\mu} \\ \mathbf{0} \end{bmatrix}, \begin{bmatrix} \boldsymbol{\Sigma} & \boldsymbol{\Sigma}\mathbf{P}' \\ \mathbf{P}\boldsymbol{\Sigma} & \mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega} \end{bmatrix} \right)$$

- for any joint normal distribution we have that

$$\begin{bmatrix} \mathbf{x} \\ \mathbf{y} \end{bmatrix} \sim N\left(\begin{bmatrix} \overline{\mathbf{x}} \\ \overline{\mathbf{y}} \end{bmatrix}, \begin{bmatrix} \mathbf{V}_{11} & \mathbf{V}_{12} \\ \mathbf{V}_{21} & \mathbf{V}_{22} \end{bmatrix} \right)$$

$$\Rightarrow \mathbf{x} \middle| \mathbf{y} \sim N\left(\overline{\mathbf{x}} + \mathbf{V}_{12}\mathbf{V}_{22}^{-1}\left(\mathbf{y} - \overline{\mathbf{y}}\right), \mathbf{V}_{11} - \mathbf{V}_{12}\mathbf{V}_{22}^{-1}\mathbf{V}_{21} \right)$$

- hence as before we obtain directly

$$E\left(\mathbf{r}_t \middle| \mathbf{g}_t\right) = \boldsymbol{\mu} + \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1} \mathbf{g}_t$$

- We are now in a position to extend the basic formulation to incorporate separate factor and stock specific forecasts

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Making use of a risk model

- In the analysis so far, the risk matrix Σ has been taken as a given
- If however we assume returns are generated according to a linear factor model then we can extend the approach to exploit that structure
- The power of Mixed Estimation lies in the ability to combine multiple forecasts - a linear factor model of returns adds the ability to forecast factor and stock specific returns directly in addition to any other portfolio forecasts we might wish to incorporate
- Furthermore, we could use the structure of the factor model to reveal whether there are any embedded factor bets in a set of portfolio forecasts that we might wish to try and neutralise in the optimisation

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Alpha Analysis

- If stock returns are described by the linear factor model $\mathbf{r}_t = \mathbf{B}\mathbf{f}_t + \boldsymbol{\varepsilon}_t$
- Then the covariance matrix is given by $\boldsymbol{\Sigma} = \mathbf{BFB}' + \boldsymbol{\Delta}$ and $\boldsymbol{\mu} = \mathbf{B}\boldsymbol{\varphi} + \boldsymbol{\alpha}$
- The distribution for factor, stock specific and forecast portfolio returns is therefore

$$\begin{bmatrix} \mathbf{f}_t \\ \boldsymbol{\varepsilon}_t \\ \mathbf{g}_t \end{bmatrix} \sim N\left(\begin{bmatrix} \boldsymbol{\varphi} \\ \boldsymbol{\alpha} \\ \mathbf{0} \end{bmatrix}, \begin{bmatrix} \mathbf{F} & \mathbf{0} & \mathbf{FB}'\mathbf{P}' \\ \mathbf{0} & \boldsymbol{\Delta} & \boldsymbol{\Delta}\mathbf{P}' \\ \mathbf{PBF} & \mathbf{P}\boldsymbol{\Delta} & \mathbf{P}\left(\mathbf{BFB}' + \boldsymbol{\Delta}\right)\mathbf{P}' + \boldsymbol{\Omega} \end{bmatrix} \right)$$

- The conditional forecasts for factor and stock specific returns given the portfolio forecasts are

$$E\left(\begin{bmatrix} \mathbf{f}_t \\ \boldsymbol{\varepsilon}_t \end{bmatrix} \middle| \mathbf{g}_t \right) = \begin{bmatrix} \boldsymbol{\varphi} \\ \boldsymbol{\alpha} \end{bmatrix} + \begin{bmatrix} \mathbf{FB}'\mathbf{P}' \\ \boldsymbol{\Delta}\mathbf{P}' \end{bmatrix} \left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega} \right)^{-1} \mathbf{g}_t$$

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Why is this useful?

- Conditional on our forecasts, $\mathbf{g}_t$, we can now compute the expected factor returns using

$$E\left(\mathbf{f}_t \mid \mathbf{g}_t\right) = \boldsymbol{\varphi} + \mathbf{F}\mathbf{B}'\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t$$

- Furthermore, given the matrix of factor loadings **B** we can decompose the conditional distribution of alpha into its factor and stock specific contributions using:

$$\begin{aligned}
E\left(\mathbf{r}_t \mid \mathbf{g}_t\right) &= \mathbf{B}E\left(\mathbf{f}_t \mid \mathbf{g}_t\right) + E\left(\boldsymbol{\varepsilon}_t \mid \mathbf{g}_t\right) \\
&= \mathbf{B}\boldsymbol{\varphi} + \boldsymbol{\alpha} + \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t \\
&= \boldsymbol{\mu} + \left(\mathbf{B}\mathbf{F}\mathbf{B}' + \boldsymbol{\Delta}\right)\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t
\end{aligned}$$

$$E\left(\mathbf{r}_t \mid \mathbf{g}_t\right) - \boldsymbol{\mu} = \mathbf{B}\mathbf{F}\mathbf{B}'\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t + \boldsymbol{\Delta}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t$$

- This decomposition is extremely useful when analysing how portfolio forecasts impact individual stock alphas

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Forecasting factor and stock specific returns

- Finally, if we extend the system to allow for simultaneous forecasts for portfolios $\mathbf{g}_t$, factors $\mathbf{g}_{f,t}$ and stock specific returns $\mathbf{g}_{\varepsilon,t}$ the resulting conditional distribution is given by

$$E\left(\mathbf{r}_t \middle| \mathbf{g}_t, \mathbf{g}_{f,t}, \mathbf{g}_{\varepsilon,t}\right) =$$

$$\boldsymbol{\mu} + \begin{bmatrix} \boldsymbol{\Sigma}\mathbf{P}' & \mathbf{BFP}' & \boldsymbol{\Delta}\mathbf{P}' \end{bmatrix} \begin{bmatrix} \mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega} & \mathbf{PBFP}'_f & \mathbf{P}\boldsymbol{\Delta}\mathbf{P}'_\varepsilon \\ \mathbf{P}_f\mathbf{FB}'\mathbf{P}' & \mathbf{P}_f\mathbf{FP}'_f + \boldsymbol{\Omega}_f & \mathbf{0} \\ \mathbf{P}_\varepsilon\boldsymbol{\Delta}\mathbf{P}' & \mathbf{0} & \mathbf{P}_\varepsilon\boldsymbol{\Delta}\mathbf{P}'_\varepsilon + \boldsymbol{\Omega}_\varepsilon \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{g}_t \\ \mathbf{g}_{f,t} \\ \mathbf{g}_{\varepsilon,t} \end{bmatrix}$$

- See Bulsing and Sefton (2002)

- Note also that the information matrix is not block diagonal hence the joint forecast is not simply the sum of the three components because the portfolio forecasts contain both embedded factor and stock specific components

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The Forecasting Audit Process

- Assume we have the following two sets of forecasts

$$\mathbf{g}_{1,t} = \mathbf{P}_1(\mathbf{r}_t - \boldsymbol{\mu}) + \mathbf{v}_{1,t} \quad \text{where} \quad \mathbf{v}_{1,t} \sim N(\mathbf{0},\ \boldsymbol{\Omega}_1)$$
$$\mathbf{g}_{2,t} = \mathbf{P}_2(\mathbf{r}_t - \boldsymbol{\mu}) + \mathbf{v}_{2,t} \quad \text{where} \quad \mathbf{v}_{2,t} \sim N(\mathbf{0},\ \boldsymbol{\Omega}_2)$$

  and we wish to check whether these two set of forecasts are mutually consistent

- We know the distribution of returns to the second set of Portfolios in the absence of any other forecasts

$$\mathbf{P}_2(\mathbf{r}_t - \boldsymbol{\mu}) \sim N(\mathbf{0}, \mathbf{P}_2\boldsymbol{\Sigma}\mathbf{P}_2')$$

  and hence we can calculate the probability of observing the forecasts $\mathbf{g}_2$

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The Forecasting Audit Process

- We also know the distribution of returns to the second set of Portfolios given the first set of forecasts

$$P_2(r_t - \mu)\big| g_{1,t} \sim N\left(P_2\Sigma P_1'\left(P_1\Sigma P_1' + \Omega\right)^{-1} g_{1,t}, P_2\left(\Sigma - \Sigma P_1'\left(P_1\Sigma P_1' + \Omega_1\right)^{-1} P_1\Sigma \right) P_2' \right)$$

and hence we can calculate the probability of observing the forecasts $\boldsymbol{g}_2$ and in the light of the first set of forecasts $\boldsymbol{g}_1$

- We can call the forecasts $\boldsymbol{g}_2$ inconsistent with the forecasts $\boldsymbol{g}_1$ if the probability of observing these forecasts has been reduced by (1-Confidence Level) , say 95%, once the forecasts $\boldsymbol{g}_1$. are incorporated into the model.

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Conclusions

- In this presentation an Enhanced Index Fund has been defined as an MV efficient portfolio designed to implement an active quantitative strategy with a low ex-ante tracking error
- It is easier to produce forecasts for a group of stocks that share a common characteristic than for individual assets
- Given a set of portfolio forecasts the challenge is to use all the available information as efficiently as possible avoiding implementation shortfall
- Bayesian Mixed Estimation techniques offer a potential solution to this problem as they provide an efficient way to combine multiple sources of forecast information
- In practice Mixed Estimation may be used to “audit” the coherence of the forecasts prior to optimisation

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Appendix A

$$E\left(\mathbf{r}_t \middle| \mathbf{g}_t\right) - \boldsymbol{\mu} = \boldsymbol{\alpha}_t = \left(\boldsymbol{\Sigma}^{-1} + \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{P}\right)^{-1}\mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{g}_t$$

by the matrix inversion theorem

$$\left(\boldsymbol{\Sigma}^{-1} + \mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{P}\right)^{-1} = \boldsymbol{\Sigma} - \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{P}\boldsymbol{\Sigma}$$

therefore

$$\begin{aligned}
\boldsymbol{\alpha}_t &= \left(\boldsymbol{\Sigma} - \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{P}\boldsymbol{\Sigma}\right)\mathbf{P}'\boldsymbol{\Omega}^{-1}\mathbf{g}_t \\
&= \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{I} - \left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}'\right)\boldsymbol{\Omega}^{-1}\mathbf{g}_t \\
&= \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\left(\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right) - \mathbf{P}\boldsymbol{\Sigma}\mathbf{P}'\right)\boldsymbol{\Omega}^{-1}\mathbf{g}_t \\
&= \boldsymbol{\Sigma}\mathbf{P}'\left(\mathbf{P}\boldsymbol{\Sigma}\mathbf{P}' + \boldsymbol{\Omega}\right)^{-1}\mathbf{g}_t
\end{aligned}$$

References

- Bulsing, M. and J. Sefton (2002) “On the nature and application of equity return forecasts” UBS Warburg
- Cochrane, J. H. (1999) “New Facts in Finance”, Economic Perspectives XXIII (3) Third quarter (Federal Reserve Bank of Chicago) http://gsbwww.uchicago.edu/fac/john.cochrane/research/Papers/ep3Q99_3.pdf
- Grinold, R. and R. Kahn (2000) “The efficiency gains of long-short investing”, FAJ vol. 56 no. 6
- Grinold, R. and R. Kahn (2000) “Active Portfolio Management” 2nd Ed. McGraw Hill
- Michaud, R. (2001) “Efficient Asset Management: A Practical Guide to Stock Portfolio Optimization and Asset Allocation” Oxford University Press, New York. Originally published by: Harvard Business School Press, 1998
- Qian, E. & R. Hua (2002) “Analysis of Cross Sectional Equity Models” Putnam Boston, February
- Satchell, S. E. and A. E. Scowcroft (2003) “Advances in Portfolio Construction and Implementation”, February, Butterworth and Heinemann, Oxford
- Scowcroft, A and J. Sefton (2003) “Enhanced Indexation”, forthcoming, in Satchell, S. E. and A. E. Scowcroft (2002)

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UBS rating	Definition	UBS rating	Definition	Rating category[1]	Coverage[2]	IB services[3]
Buy 1	Excess return potential > 15%, smaller range around price target	Buy 2	Excess return potential > 15%, larger range around price target	Buy	47%	35%
Neutral 1	Excess return potential between -15% and 15%, smaller range around price target	Neutral 2	Excess return potential between -15% and 15%, larger range around price target	Hold/Neutral	47%	32%
Reduce 1	Excess return potential < -15%, smaller range around price target	Reduce 2	Excess return potential < -15%, larger range around price target	Sell	6%	26%

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