Climate Risk Hedging

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Text as Data

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$$tf_{i,j} - idf_j = \frac{c_{i,j}}{n_i} \times \log(\frac{n}{d_j}) \tag{1.1}$$

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Chapter 2

Factor Signal

2.1 Regression and Few Statistics

We will run *regression* to estimate the *beta coefficient*. For example, we can regress a return on the market return:

$$R_t = \alpha + \beta R_{m,t} + \epsilon_t \tag{2.1}$$

We can also do it with the returns of several other portfolios:

$$R_t = \alpha + \beta_m R_{m,t} + \gamma R_{p,t} + \epsilon_t \tag{2.2}$$

The *population value* of the beta coefficient with the single factor model is:

$$\beta = \frac{Cov(R, R_m)}{Var(R_m)} \tag{2.3}$$

The regression recovers the *true* (*i.e.* unbiased) β only if the *error term* ϵ is *uncorrelated* with the right hand variables (R_m in our first case).

In the multiple regression example, β_m captures the effect on the return of only movements in the market portfolio that are not correlated with movement in the other portfolio p.

2.2 Simple Factor Mimicking Portfolio

Factor mimicking is a useful practice in finance. The core idea is to replace some variables with a linear combination of other variables. More specifically, **some variable of interest can be written as a portfolio of *tradable assets***. It can be used to proxy economic variable that are not directly observable with tradable assets.

This is the idea from Lamont (2001): we can construct, from financial assets, a "matching portfolio" of some economic factor that is not directly observable (in the case of Lamont, the idea was to forecast variables).

Say you want to estimate current (this is *nowcasting*) GDP or inflation. You can construct the portfolio of assets that best mimics the movements of GDP or inflation. Once you've run your regression, you can use your estimate of returns to predict the macro variable.

Let's say we don't have individual stock returns and we want to estimate the market return. All what we have is the return of K industry portfolios. We can estimate the market return as a linear combination of the industry returns:

$$R_{m,t} = \beta_{\text{energy}} R_{\text{energy},t} + \beta_{\text{financials}} R_{\text{financials},t} + \ldots + \beta_k R_{k,t} + \epsilon_t \tag{2.4}$$

It looks very much like a portfolio, with the estimated β as the weights of the assets.

2.3 Mimicking Factor Signal

Now, let's say we want to form a portfolio that mimics the behavior of a *factor signal* y. Specifically, our target is "news" or *innovations* about the signal, defined as the difference between the current expectation and the previous expectation:

$$\Delta E_t(y_{t+1}) := E_t(y_{t+1}) - E_{t-1}(y_{t+1}) \tag{2.5}$$

In can be for example the news that the market learns about the industrial production in May about the industrial production in June.

The mimicking portfolio portfolio returns are:

$$R_{y,t} = w^T R_t \tag{2.6}$$

where R_t is the vector of returns of the tradable assets. You construct the mimicking portfolio with *unexpected returns* of the tradable assets. Unexpected returns are actual returns minus expected returns:

$$\tilde{R}_t := R_t - E_{t-1}(R_t) \tag{2.7}$$

with the assumption that **the expected returns are a linear function of factors F_t**:

$$E_{t-1}(R_t) = \gamma^T F_t \tag{2.8}$$

The porfolio weights of the mimicking portfolio of y are chosen so that $\tilde{R}_{y,t}$ is as close as possible to $\Delta E_t(y_{t+1})$ (maximally correlated).

To do this, the key assumption is that **innovations in returns (unexpected returns) reflect innovations in expectations about the factor signal**, such that:

$$\Delta E_t(y_{t+1}) = \beta^T \tilde{R}_t + \epsilon_t \tag{2.9}$$

If the factor signal y is correlated with future cash flows and discount rates, then we may find something in the β, relating news reflected in the unexpected returns. Again, this is based on the assumption that the unexpected returns reflect news about the future cash flows and discount rates (*i.e.* about $\Delta E_t(y_{t+1})$).

Recalling that the returns are $R_t = E_{t-1}(R_t) + \tilde{R}$, we can therefore rewrite it with the factors:

$$R_t = \gamma^T F_t + \tilde{R} \tag{2.10}$$

and then includes the innovations in the factor signal:

$$R_t = \gamma^T F_t + \eta \Delta E_t(y_{t+1}) + u_t \tag{2.11}$$

What we have here? **The returns of any asset can be written as a function of its expected returns ($\gamma^T F_t$) and the unexpected returns. The unexpected returns are decomposed into the news about the factor signal $\Delta E_t(y_{t+1})$ and uncorrelated errors (u_t).**

2.4 Climate Factor Signal

$$CC_t = w^T \tilde{R}_t + \epsilon_t \tag{2.12}$$

We can use the same basic idea to find the portfolios that mimic the behavior of a climate factor. For each portfolio i, we can run:

$$R_{i,t} = \beta_i CC_t + \gamma_i^T \text{Factors}_t + \epsilon_{i,t} \tag{2.13}$$

With the estimated β_i can be a first estimate for portfolio's weights that mimic the climate factor.

Long-only factor mimicking.

Chapter 3

Efficient Porfolio

3.1 Portfolio Optimization

3.2 Efficient Mimicking Portfolio

Chapter 4

Estimation of the Covariance Matrix

4.1 Covariance Matrix Estimation

4.2 Shrinkage Estimation