Climate Risk Hedging

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Chapter 1

Introduction

We consider alternative approaches for climate risk hedging. All approaches share the same goal: to be long stocks that do well in periods with unexpectedly bad news about climate risks, and short stocks that do badly in those scenarios.

Chapter 2

Simple Economic Tracking Portfolio

EXPLANATIONS RETURNS AND STATS HERE

The portfolio constructed here has unexpected returns with maximum correlation with news about future macroeconomic variables.

Empirical finance has a long tradition of explaining current returns with other current returns.

2.1 Basics

2.1.1 Modelling Returns

2.1.2 Statistics

2.2 Forming Tracking Portfolio with Regression

REGRESSIONS EXPLANATIONS HERE

A tracking portfolio for any variable y can be obtained as the fitted value of a regression of y on a set of base asset returns. The portfolio weights for the economic tracking portfolio for y are identical to the coefficients of an OLS regression. If y happens to be a state variable for asset pricing, then a multi-factor model holds with one of the factors being the y's tracking portfolio.

However, even if y is not a state variable for asset pricing, its tracking portfolio is still an interesting object, since it reveals changes in market expectation about y.

The following three statements are equivalent description of an economic tracking portfolio:

1. the portfolio has the minimum variance out of all portfolios with a given beta (univariate regression coefficient) in a regression portfolio return on y.

2. has returns with the maximum possible correlation with y.

3. has the highest R-squared in a regression of y on the portfolio returns.

These properties come directly from the definition of an OLS regression.

2.3 Python Project: Tracking the Market Portfolio

2.4 Conclusion

Chapter 3

Economic Tracking Portfolio for News

3.1 Basics

3.1.1 Time Series

3.1.2 Predicability

3.2 Tracking the Unexpected

PREDICTABILITY EXPLANATIONS HERE

This paper constructs portfolios with unexpected returns that are maximally correlated with unexpected components of future y. Specifically, the target variable is *news* about y_{t+k}, where y_{t+k} is a macroeconomic variable in period $t+k$.

News is innovation in expectations about y_{t+k}, with notations:

$$\Delta E_t(y_{t+k}) = E_t(y_{t+k}) - E_{t-1}(y_{t+k}) \tag{3.1}$$

For example, $\Delta E_t(y_{t+k})$ can be the news the market learns in July 2021 about the GDP growth rate in 2022.

The tracking portfolio returns are:

$$r_{t-1,t} = bR_{t-1,t} \tag{3.2}$$

where $r_{t-1,t}$ is the return of the tracking portfolio, $Rt-1,t$ is a column vector of asset returns from the end of period $t-1$ to the end of period t, and b is a row vector of portfolio weights.

The tracking portfolio is constructed using unexpected returns on the base assets. The unexpected returns are actual returns minus expected returns:

$$\tilde{R}_{t-1,t} = R_{t-1,t} - E_{t-1}(R_{t-1,t}) \tag{3.3}$$

The portfolio weights are chosen so that $\tilde{r}_{t-1,t}$ is maximally correlated with $\Delta E_t(y_{t+k})$.

Estimating tracking portfolios for news is only slightly more complicated than estimating simple tracking portfolios. One can always write a projection equation of news on unexpected returns. The key assumption in this paper is that innovations in returns reflect innovations in expectations about future variables, so that the vector a has non-zero elements in the projection equation:

$$\Delta E_t(y_{t+k}) = a\tilde{R}_{t-1,t} + \eta_t \tag{3.4}$$

where η_t is the component of news that is orthogonal to the unexpected returns. Since unexpected returns reflect news about future cash flows and discount rates, a will generally be non-zero for any variable correlated with future cash flows or discount rates (there is no intercept in the equation above).

It seems at first glance that one needs to obtain $\Delta E_t(y_{t+k})$, the period t news about y_{t+k}, to run the regression. In fact, all that is needed is $\tilde{R}_{t-1,t}$, the unexpected returns. The realization of y_{t+k} can be written as the sum of the expectation in period $t-1$, the innovation in expectations in period t, and the innovation in expectations from period t to period $t+k$:

$$y_{t+k} = E_t(y_{t+k}) + e_{t,t+k} = E_{t-1}(y_{t+k}) + \Delta E_t(y_{t+k}) + e_{t,t+k} \tag{3.5}$$

The second assumption made here is that expected returns on the base assets in period t are linear functions of Z_{t-1}, a vector of control variables known at period $t-1$:

$$E_t(R_{t-1,t}) = dZ_{t-1} \tag{3.6}$$

3.3 Python Project: Tracking GDP

3.4 Conclusion

Chapter 4

Climate Risk Mimicking Portfolio

4.1 Basics

4.1.1 Mimicking Portfolio

4.1.2 Climate Risk

4.1.3 Climate News

EXPLAIN CLIMATE TRANSITION VS. PHYSICAL RISK EXPLAIN CONSTRUCTION CLIMATE hedge

4.2 Risk Mimicking Portfolio

The mimicking portfolio approach combines a pre-determined set of assets into a portfolio that is maximally correlated with a given climate change shock, using historical data. To obtain the mimicking portfolios, we estimate the following regression model:

$$CC_t = wR_t + \epsilon_t \tag{4.1}$$

where CC_t denotes the (mean zero) climate hedge target in month t, w is a vector of N portfolio weights, R_t is the $N \times 1$ vector of unexpected excess returns and ϵ_t is the regression residual. The portfolio weights are estimated each month using a rolling window of T months of historical data.

4.3 Python Project: Climate Risk Mimicking Portfolio

4.4 Conclusion