Asset Allocation: Coding Challenge

Case Study: Asset Allocation Model

The Asset Allocation Squad identifies relative performance opportunities in international multi-asset markets for tactical portfolio decisions. Applying Machine Learning to Asset Pricing problems helps us to discover non-linear relationships between the macroeconomic environment and systemic risk.

Imagine you are part of our squad. A hypothetical institutional investor would like to analyze how tilting the equity-riskfree bond ratio in their portfolio impacts future performance. Our data engineers have provided you with a dataset (`data.csv`) of daily nominal realized returns.

Variables in `data.csv`:

- `Return_with_Dividends`: The realized equity return over the past year with dividends

$$H_t \equiv \frac{P_t + D_{t-1Yr,t}}{P_{t-1Yr}} - 1$$

  where P_{t-1Yr} is the price one year ago and $D_{t-1Yr,t}$ the accumulated nominal dividend payout over the past year
- `Return_without_Dividends`: The realized equity return over the past year without dividends

$$V_t \equiv \frac{P_t}{P_{t-1Yr}} - 1$$

- `RiskFree_Rate_1Month_Forward`: The nominal risk-free rate for the next 30 days, $R_{f,t}$
- `Return_1Month_Forward`: The realized equity return with dividends over the next 30 days

$$R_t \equiv \frac{P_{t+30d} + D_{t+30d,t}}{P_t} - 1$$

- `Sigma`: The conditional volatility of the equity return with dividends over the next 30 days

$$\sigma_t \equiv \sqrt{Var_t(R_t)}$$

Example: The row on the 2000-01-01 will provide you with the backward looking returns from 1999-01-01 to 2000-01-01 and the forward looking return 2000-01-01 to 2000-01-31.

Part A: Return Forecasting

The team has the hypothesis that the Price-to-Dividend ratio

$$PD_t \equiv P_t / D_{t-1Yr,t}$$

and the corresponding time-series for the log dividend growth over the past year, i.e.

$$\Delta d_t \equiv \log\left(D_{t-1Yr,t} / D_{t-2Yr,t-1Yr}\right)$$

predict returns.

1. Construct the two new variables using H_t and V_t.
2. Can you develop a model based on PD_t and Δd_t which predicts the return R_t?

Part B: Asset Allocation

The one month forward portfolio return with two assets is defined as

$$R_{p,t} \equiv \alpha_t R_t + (1 - \alpha_t) R_{f,t}.$$

Without frictions, the optimal short-term allocation decision for an investor with mean-variance preferences is given by

$$\alpha_t = \frac{E_t[R_t] - R_{f,t}}{k\sigma_t^2}$$

where $k > 0$ is the risk aversion coefficient.

1. Use your expected return estimates from Part A to compute the time-series for the optimal portfolio decision $\alpha_t(k)$.
2. Plot the average portfolio $E[R_{p,t}]$ return and the volatility $Var(R_{p,t})$ as a function of k.

If possible, please send us your Python code/solution within 10 days as a `.zip` or `.tar.gz` archive. Include comments and explanations and make sure that your code is accompanied by a README with installation and execution instructions. This will ensure that we can review your work in a timely manner.

If there are any uncertainties or questions regarding the task, please do not hesitate to reach out to Andreas (`fuest@othoz.com`).