MATHGR5380 Project2: Dynamic Factor-based GTAA

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Our report aims to introduce the process of how we create and back-test a dynamic factor-based long-short GTAA portfolio based on Markov Regime-Switching model. It consists of three main parts: a brief introduction of data processing, description of our two strategies, and a summary of the backtest results.

Data Processing

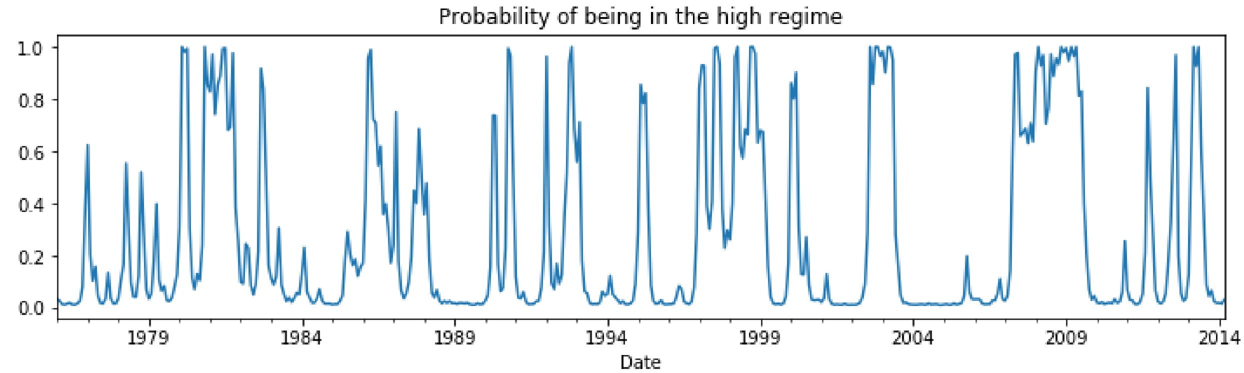
Given the 10 developed country MSCI indices and forward P/E from December 1972 to March 2014, we calculate the index returns, the 12-month momentum with last month skipped, the 12-month momentum factor portfolio weights, the ranked FEP, and the value portfolio holdings. We use all the data above to build up our strategies.

Description of the Strategy

Our strategy is designed by selecting value and momentum factors based on turbulence regimes. According to some research, in high-variance regimes, value stocks tend to perform better, and in low-variance regimes, the momentum stocks give better returns. Hence, we use two 2-state Markov Regime-Switching models to construct two similar strategies. Here are the steps:

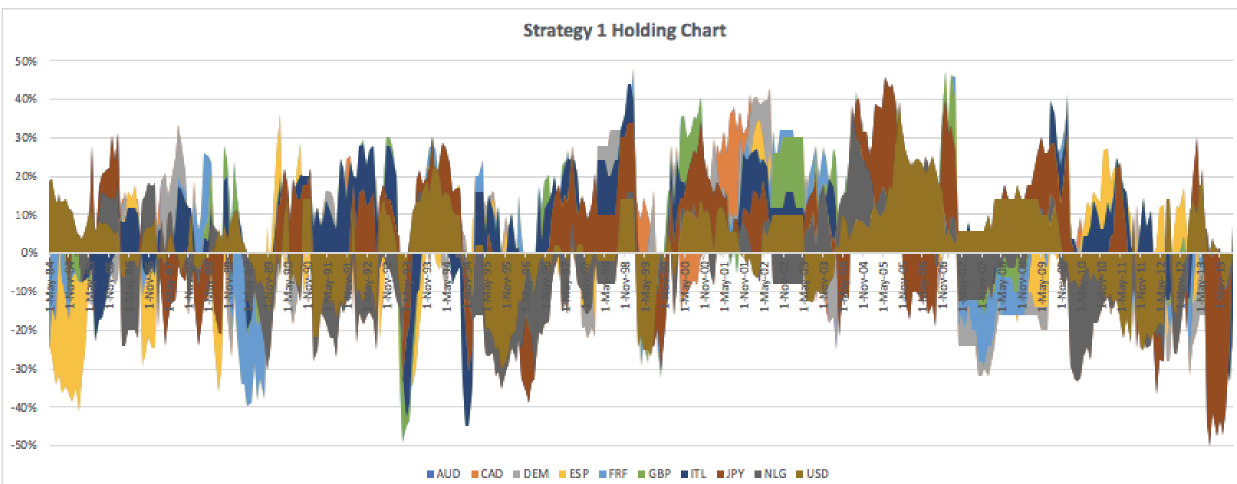
- Calculating a turbulence measure based on prior 36-month index returns as follows $d_t = (y_t - \mu) * \Sigma * (y_t - \mu)'$
- Applying the turbulence measure to two Markov Regime-Switching models
    1. Using the regular Markov Regression
    2. Using an order-2 Markov Auto-regression which assumes an AR(2) process of the turbulence time series
- Identifying regimes and determining the factor to be used
    1. Using the Value factor in high turbulence regime
    2. Using the Momentum factor in low turbulence regime

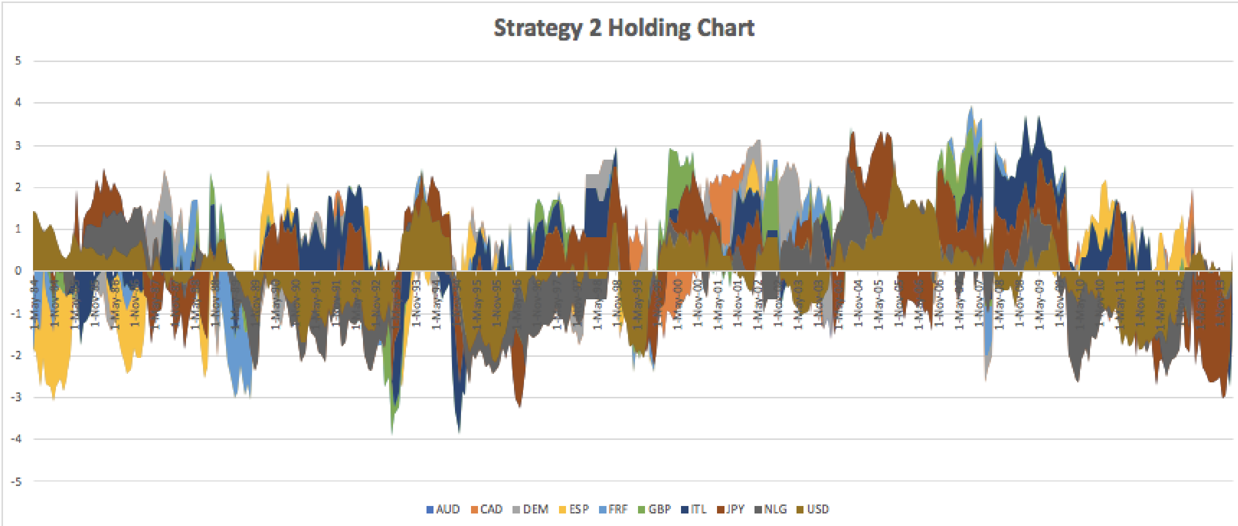
The below graph shows the probability of a certain moment being in high-turbulence regime using the regular Markov Regression.



Backtest Results

Here are the weight holding chart and return chart for each strategy:





Summary of the Results

For backtesting, we calculate annualized volatility of each asset for each month and correlation matrix of the assets for the final period. Based on our estimated covariance matrix, we scale the two strategy portfolios to 1% risk and get resulting holdings.

Here are the statistics tables for the two strategies.

Strategy 1 Portfolio at 1% Risk stats

Arithmetically Annualized Return	0.35%
Annualized Realized Risk	1.08%
Return to Risk Ratio	31.96%
Geometrically Annualized Return	0.34%

Average Drawdown	1.07%
Annual Turnover	137.88%

Strategy 2 Portfolio at 1% Risk stats

Arithmetically Annualized Return	0.32%
Annualized Realized Risk	1.04%
Return to Risk Ratio	30.98%
Geometrically Annualized Return	0.32%
Average Drawdown	0.84%
Annual Turnover	124.09%

Comments & Further

1) We find from our back-test results that the strategy using Markov Autoregression underperforms the other one, which may indicate that the turbulence time series doesn't follow an AR(2) process. It may be worth trying some different time-series models to improve our results.
2) We also notice that our strategies are quite volatile which might be due to frequent shifting between the two factors. It would be a good future study to deal with this problem.

Appendix

Code snippets in Python (fit the Markov regression models) and Matlab (compute the turbulence measure and COV)

```python
%matplotlib inline

import numpy as np
import pandas as pd
import statsmodels.api as sm
import matplotlib.pyplot as plt
from io import BytesIO
from datetime import datetime
```

```python
dta = pd.read_excel(r'C:\Users\likeb\Documents\Columbia Documents\Spring 2020\Multi-asset Portfolio Management\Final Project\Fina
                    sheet_name = "turbulence(t)")
print(dta)
dta.index = pd.DatetimeIndex(dta.Date)
dta_regime = dta.Turbulence
#dta_regime.plot(title='Turbulence', figsize=(12,3))

# Fit the model
regime_model = sm.tsa.MarkovRegression(dta_regime, k_regimes=2, switching_variance=True)
#regime_model = sm.tsa.MarkovAutoregression(dta_regime, k_regimes=2, order = 2, trend = 'nc', switching_variance=True)
res_regime = regime_model.fit()

res_regime.summary()

res_regime.smoothed_marginal_probabilities[1].plot(
    title='Probability of being in the high regime', figsize=(12,3));
```

```matlab
% FINAL PROJECT
% load MSCI indices returns from excel file

filename = 'C:\Users\likeb\Documents\Columbia Documents\Spring 2020\Multi-asset Portfolio Mana
[data,txt] = xlsread(filename, 'MARKOV_REGIME_SWITCHING_MODEL', 'M2:W498');
returns.header = txt(1,2:end);
returns.dates = txt(3:end,1);
returns.data = data;

windowLength = 36; % length of rolling window for COV estimation
% initialize COV data structure as 3-dim matrix, 3rd dimension is date
COV.header = returns.header; K = numel(COV.header);
COV.dates = returns.dates(windowLength:end); L = length(COV.dates);
COV.data = NaN(K,K,L);
% calculate COV matrix for each month t
for t = windowLength:length(returns.dates)
 RollingWindow = returns.data(t-windowLength+1:t,:);
 [~, ExpCovariance] = ewstats(RollingWindow,1,windowLength);
 COV.data(:,:,t+1-windowLength) = ExpCovariance*12;
end

turbulence(1:L-1) = 0;
for i = 1:L-1
    yt_minus_miu = returns.data(i+windowLength-1,:)-mean(returns.data(i+windowLength-1,:));
    turbulence(i) = yt_minus_miu*(COV.data(:,:,i)^(-1))*yt_minus_miu.';
end
```

```matlab
%xlswrite(filename, turbulence.', 'turbulence(t)');

% calculate volatility for unadjusted portfolio holdings

[data2,~] = xlsread(filename, 'factor holdings', "B140:K498");
[data3,~] = xlsread(filename, 'factor holdings', "N140:W498");
weights2 = data2;
weights3 = data3;
[numRows2, ~] = size(data2);
rows2 = min(numRows2, L);
value2(1:rows2) = 0;
for i = 1:rows2
    a = weights2(i,:)*COV.data(:,:,100+i);
    value2(i) = sqrt(a*weights2(i,:).');
end

[numRows3, ~] = size(data3);
rows3 = min(numRows3, L);
value3(1:rows3) = 0;
for j = 1:rows3
    b = weights3(j,:)*COV.data(:,:,100+j);
    value3(j) = sqrt(b*weights3(j,:).');
end

xlswrite(filename, value2.', 'Volatilities1');
xlswrite(filename, value3.', 'Volatilities2');

xlswrite(filename, corrcov(COV.data(:,:,459)), 'Correlation final period1');
xlswrite(filename, corrcov(COV.data(:,:,459)), 'Correlation final period2');
```