HOMEWORK2 (Practical Introduction to Quantitative Trading)

December 3, 2019

Please solve one of the following problems. Obviously you are welcome to solve both.

1 Problem 1: (Pairs Trading Strategy)

Select a pair of stocks or any other instruments (not necessarily tradable for example broad market indexes).

Question 1: Try to rationalize your choice of instruments. What are the economic reasons for tight price relationship?

Question 2: Below we denote price series for these instruments as $A(t)$ and $B(t)$. Try to apply "Cointegration approach". For each date "t" select "In sample" period $[t-L, t-1]$ where L is the length of the time window used for training.

Estimate residuals via the following linear regression:

$$A(\tau) = \alpha + \beta * B(\tau) + R(\tau), \tau \in [t-L, t-1]$$

where α is intercept and β is regression coefficient and $R(\tau)$ is time series of residuals. Construct Z-scores, defined as $Z(\tau) = \frac{R(t)}{S(\tau)}$ where $S(\tau)$ is the volatility of the residual.

Question 3: For each "In sample" $[t-L, t-1]$ period estimate optimal entry and exit points by analyzing the behavior of $Z(t)$. Apply these trading rules to the "out of sample period" $[t+1, t+W]$ where W is the length of the window used for trading.

Question 4: Calculate cumulative pnl, sharpe ratio and drawdowns of your strategy.

Question 5: Explore the sensitivity of your strategy to change in parameters: L, W and entry and exit points.

2 Problem 2 (Hedging using ETFs)

Assume you have stock portfolio with value $\sum_{i=1}^{N} n_i P_i$ where n_i is number of shares of stock "i" and P_i is the price of the stock "i" . Find a way to hedge a market exposure using broad market ETF "SPY" (tracking S&P500 index). Start by describing the methodology for estimating sensitivity of each stock return $r_i(t) = log(\frac{P_i(t+1)}{P_i(t)})$ versus return of the SPY denoted $m(t)$ below.

$$r_i(\tau) = \alpha_i + \beta_i m(\tau) + \epsilon_i(\tau), \tau \in [0, T]$$

$$\epsilon_i(\tau) \in N(0, \sigma_i)$$

Question 1: Describe methodology to estimate $\beta_i(\tau)$. How would you handle outliers?

Question 2: Is it possible to have $\beta_i <= 0$? Describe different scenarios where it can happen.

Question 3: Given set of β_i and current price of ETF P_{spy} calculate the desired hedging trade which will neutralize market exposure of the portfolio.

Assume your portfolio has only stocks from 2 sectors: Energy and Financial stocks. Devise a scheme to hedge sector exposures of the portfolio using broad sector ETFS (XLF - "Financial stocks", XLE - "Energy").

$$r_i(\tau) = \alpha_i + \beta_i M_e(\tau) + \gamma_i M_f(\tau) + \epsilon_i(\tau)$$

$$\epsilon_i(\tau) \in N(0, \sigma_i)$$

where $M_e(\tau)$ is return of XLE, $M_f(\tau)$ return of XLF. Assume that returns of XLF and XLE are correlated

$$\rho = E((M_e(\tau) - E(M_e))(M_f(\tau)) - E(M_f))$$

Question 4: Given set of β_i and γ_i calculate the desired hedging trades using XLF and XLE in order to neutralize the sector exposure of your portfolio.