1. (30%) The following is a scenario for three stocks constructed by the security analysts of a corporation.

<table>
<thead>
<tr>
<th>Stock</th>
<th>Price ($)</th>
<th>Recession</th>
<th>Average</th>
<th>Boom</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>-15</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>25</td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td>C</td>
<td>50</td>
<td>12</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>

(a) (15 %) Construct an arbitrage portfolio using these stocks.

(b) (15 %) How might these prices change when equilibrium is restored? Give an example where a change in Stock C’s price is sufficient to restore equilibrium, assuming that the dollar payoffs to Stock C remain the same.

2. (10%) What are the differences between characteristic-based model and the APT-based factor model?

3. (10%) Briefly explain why does Fama and French’s three-factor model include the market return as a factor, even though they find that beta is dead?

4. (10%) Suppose you solve the following two ‘index tracking’ problems:

\[(Q_1) \quad \min_{\{w_1, \ldots, w_N\}} \sum_{t=1}^{T} \left( \sum_{i=1}^{N} w_ir_{it} - m_t \right)^2, \quad s.t. \quad \sum_{i} w_i = 1.\]

where \(m_t = \frac{l_t - l_{t-1}}{l_{t-1}}\) is the return on a value-weighted benchmark portfolio.

\[(Q_2) \quad \min_{\{w_2, \ldots, w_N\}} \sum_{t=1}^{T} \left( \frac{\sum_{i=1}^{N} w_iP_{it}}{\sum_{i=1}^{N} w_iP_{i,t-1}} - (1 + m_t) \right)^2, \quad s.t. \quad w_1 = 1;\]

Which one yields smaller tracking error? Which one might entail higher transaction cost?
5. (10%) Suppose a stock has a beta of 0.8. Calculate the proportion of unsystematic risk to its total variance.

6. (40 %) Yes-or-no questions and brief explanations, as usual. 5 points each.

   (a) If a $k$-factor APT holds ($k > 1$), then it is necessary the case that the CAPM will not hold.

   (b) If the efficient market hypothesis does not hold, then the CAPM will not hold.

   (c) If a mutual fund has a negative measure of Jensen’s alpha, its manager has a poor selectivity ability.

   (d) In equilibrium, all passive portfolios have the same Treynor’s performance ratio.

   (e) If contrarian strategies are profitable, it implies that stock returns are predictable.

   (f) If an arbitrage portfolio generates statistically significant positive profits, it implies that there exist arbitrage opportunities, and the market is not efficient.

   (g) If returns on individual securities do not exhibit any autocorrelations, then an equal-weighted portfolio composed of the stocks will also be serially uncorrelated.

   (h) Since the APT assumes that all common factors have zero means, but the expected return on market portfolio is positive in equilibrium, the APT will not hold if the CAPM holds.