FE570A Final Exam (Fall 2018)

Due Date: In-class (December 11th).

Exam Honor Policy: You are NOT allowed to discuss the problems among yourselves. You must answer the exam questions independently, and cannot show one another any parts of your solutions.

Instructions: This exam includes two parts. The first part is close book/notes (50 points). You will have 60 minutes to finish and submit it in class. The second part will be data analysis which includes one problem (50 points). Dataset used in this part is available from the course website on Canvas. You are allowed to look at only the class website, and no other Internet resources will be allowed during this part of the exam. You will have 120 minutes to finish and submit the results to the course website. After the designated time the submission site will be closed. No extension will be allowed.

Part I - Answer briefly the following questions (50 points).

Note: each question has different points of weight.

1. Market risk is resulted from unexpected changes in the market prices, interest rates, or foreign exchange rates. Historical volatility calculated using the daily returns is the most straightforward measure of market risk. Can you name 4 other market risk measures? Describe briefly how each works. (5 pts)

2. Moving-average filtering rules are defined based on two smoothing mechanism. The first one is called simple moving average SMA. Let's denote SMA over n lagged periods at time t with $sma(P_t, n)$:

$$\text{sma}(P_t, n) = (P_{t-1} + P_{t-2} + ... + P_{t-n})/n$$

and consider the relative difference between the short-term (fast) $sma(P_t, S)$ and the long-term (slow) $sma(P_t, L)$:

$$r_t = [\text{sma}(P_t, S) - \text{sma}(P_t, L)]/\text{sma}(P_t, L)$$

The moving-average strategy generates the following trading signals:

$$\text{Sell: } r_t > \delta$$
$$\text{Buy: } r_t < -\delta$$

Assume $\delta = 0.12$, $S = 2$, and $L = 4$. Please use the prices listed in the table below to calculate r_t and determine the Buy/Sell/Hold signals for time $4, 5, 6$. Please fill the blank cells in the following table and explain the calculation if it is necessary. (15 pts)

(k)	1	2	3	4	5	6
(p_k)	9.90	8.42	6.12	6.30	7.85	9.50
$sma(p_t, 2)$	-	-				
$sma(p_t, 4)$	-	-	-	-		
r_t	-	-	-	-		
$Buy/Sell$	-	-	-	-		

3. The standard technique offered by Engle and Granger for finding if two time series are cointegrated is derivation of the linear regression

$$x_t = \alpha y_t + c + \epsilon_t \tag{1}$$

The residuals ϵ_t are then tested for stationarity. Usually, the Augmented Dickey-Fuller (ADF) test is used for unit roots test. If stationarity is not rejected, then the cointegration condition holds. In the context of cointegrated portfolio, the residuals are sometimes called

tracking errors. Can you summarize this procedure as a 2-step process to determine α and c, and then test ϵ_t for unit roots? (5 pts)

4. Time-weighted average price (TWAP) is a performance measure where child orders are spread uniformly over a given time interval, while Volume-weighted average price (VWAP) is a very popular benchmark method to quantify execution performance. If an asset during some time interval has N trades with price p_k and volume v_k, its VWAP is

$$\text{VWAP} = \sum_{k=1}^{N} v_k p_k / \sum_{k=1}^{N} v_k \tag{2}$$

Jeremy is a trader and he was asked to sell $20,000$ shares of AAPL stock. He finished his typical 6 hours trading day with the following trading records in a spreadsheet:

Period (k)	1	2	3	4	5	6
Volume (v_k)	2500	2300	1200	1100	3300	2400
Price (p_k)	244.90	236.49	244.12	267.24	226.45	260.40

Each of the six periods is one hour.

a). Please calculate both VWAP and TWAP (hint: a simple average for the six periods is TWAP). (6 pts)

b). What is the difference and why traders would prefer to use VWAP? (4 pts)

5. The autoregressive AR(p) model is in the same form as a multiple linear regression model with lagged values serving as the explanatory variables. In an AR(1) model, the lagged return r_{t-1} is useful in predicting r_t:

$$r_t = \phi_0 + \phi_1 r_{t-1} + a_t, \tag{3}$$

where $\{a_t\}$ is defined as i.i.d. white noise series with mean zero and variance σ_a^2, and it is uncorrelated with r_t.
Assume we have $E(r_t) = \mu$, $Var(r_t) = \gamma_0$, and $Cov(r_t, r_{t-j}) = \gamma_j$.

a). What is the value $E[(r_t - \mu)a_{t+1}]$? Why? (5 pts)

b). If we fit an AR(1) model for a market return and we find that ϕ_1 is significantly different from zero, can we say this market is efficient? Why. (5 pts)

c). We can also obtain $\gamma_0 = \frac{\sigma_a^2}{1-\phi_1^2}$, and $\gamma_\ell = \phi_1 \gamma_{\ell-1},$ for $\ell > 0$. Assume σ_a^2 and ϕ_1 are constants. Is the time series generated from the model stationary? Why? (5 pts)

PART II - Strategy Design(50 points)

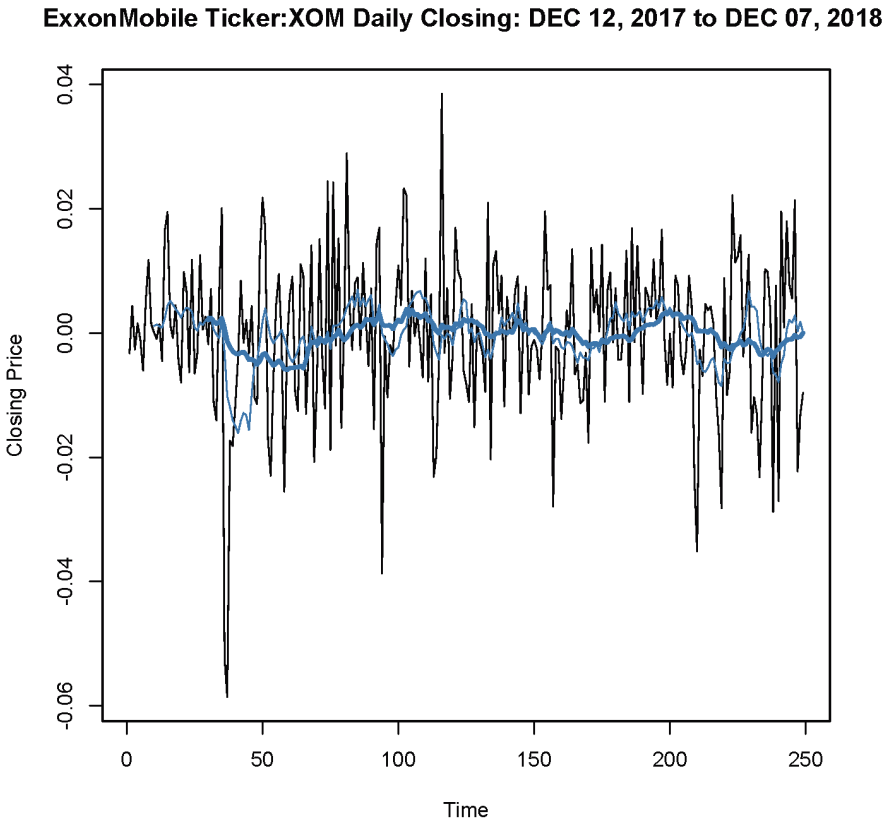
Problem Description: Consider the daily stock price for ExxonMobile (XOM) from December 12, 2017 to December 7, 2018 in the file XOM.CSV. In this problem, you are given $10,000 capital to invest. Your goal is to maximize your client's profitability. But at the same time, you need to measure your investment risk based on your client's risk utility. Here we assume that your client is risk averse, but she is willing to adjust her risk position, if she can be convinced. You are considering design a trading strategy for XOM stock based on this one year historical data. You need to write a proposal to your client about your strategy, performance and describe your back testing procedure.

Note: You will use S&P 500 Index Annual Return as the benchmark $r_f = 5.11\%$ for the 2017-2018 period. You are to use log return to calculate r_i for each of your trades as:

$$r_i = log\left(\frac{\text{Close Price}}{\text{Last Close Price}}\right)$$

Assignment: You will need to do the following for this assignment:

(1) Assume that you are considering many strategies, but particularly you are testing Moving Average Convergence/Divergence (MACD) at this point. Create a momentum trading strategy based on MACD method to invest $10,000 client's money. Note that you need to use the fast EMA (12 days) and the slow EMA (26 days), and 9 days for the $signal\text{-}line = ema(MACD_t; 9)$ for this assignment. Note that your broker allows you to short sell. Each pair of long/short or short/long actions will be considered as a transaction. Assume there is a $5 transaction cost. You need to provide a table of the buy and sell signals for the entire period with dates, and calculate profit when you close a position.



Please provide the average return and variance of return for the entire period. (20 points)

(2) To simplify the problem, hedging is not part of your assignment. However, you do need to measure your risk. Suppose you can use S&P 500 Index return during the same period as your risk free rate. Measure your risk adjusted performance using *Sharpe ratio*:

$$R_{Sharpe} = E[r_i - r_f]/\sqrt{Var(r_i - r_f)}$$

where r_f is the risk-free asset return, r_i is return at time i, and $\sqrt{Var(r_i - r_f)}$

is the standard deviation of the asset's excess return at time i. **Please calculate Sharpe ratio for from the previous question.** [*Hint: calculate excessive return for each of your returns* $(r_i - r_f)$ *to the Sharpe ratio, and* r_f *is only different for different years.*] (10 points)

(3) Assume you choose parameter m for the $signalline = ema(MACD_t; m)$ to optimize your strategy. You need to evaluate the options of $m = 7, 9,$ and 11. **Please calculate Sharpe ratios for the three options and choose one best strategy for your client.** (20 points)