Last Name: _____ First Name: _____

M.I.T. ID# _____

15.450 Final Exam

Professor Hui Chen

Spring 2018

Please read the following instructions carefully.

- Please write your name and MIT ID number on the first two pages.
- The exam lasts 180 minutes. Please try to answer each of the questions.
- You are allowed two $8\frac{1}{2}$"$\times$11" sheets of formulas and one calculator.
- Answer these questions without consulting anyone.
- Always explain your answers and show your work, but try to be concise. Answers without explanations will receive no credit. Wrong answers with partially correct work may receive partial credit.

Good luck!

Name: _____ MIT ID#: _____

15.450 Final Exam Grade Sheet

1.	_____	/	60
2.	_____	/	10
3.	_____	/	20
4.	_____	/	10
Total	_____	/	100

1. (60 points) **SHORT QUESTIONS** (Please briefly explain your answers.)

   (a) (7 points) Explain intuitively why a GARCH model generates heavy tails in the unconditional return distribution even though returns are conditionally normal.

   (b) (7 points) You are building a logistic model for corporate defaults. The response variable $Y_{it} = 1$ if firm i defaults in year t, and $Y_{it} = 0$ otherwise. Among the list of predictors is $TLTA$, which is a leverage ratio measure based on firm i's total liability divided by total assets in year $t-1$. The MLE coefficient for $TLTA$ is 3.36. Please interpret the meaning of this coefficent.

(c) (15 points) For each of the scenarios below, indicate whether we would generally expect the performance of a linear model fitted using OLS to be better or worse than using a shrinkage method such as ridge regression or LASSO. Justify your answer.

i. The sample size n is extremely large, and the number of predictors p is small.

ii. The number of predictors p is extremely large, and the number of observations n is small.

iii. The variance of the error terms, i.e., $\sigma^2 = \text{Var}(\epsilon)$, is extremely high.

(d) (8 points) In an event study of stock returns around earnings announcements, how should we deal with the fact that multiple firms announce their earnings on the same days?

(e) (8 points) You have developed a classification model to detect credit card frauds. Based on the various information of a card applicant, the model produces the probability that the application is fraudulent. Explain how you would use this model to make the decision to approve or deny an application.

(f) (7 points) In order to better advise clients on designing compensation packages, you are studying the determinants of CEO compensation across firms. You are quite aware of the fact that both firm size and CEO's managerial ability should be important determinants of compensation, but unfortunately you do not have data to measure the abilities. Instead, you estimated the following model,

$$y_i = \beta_0 + \beta_1 SIZE_i + \epsilon_i,$$

where y_i measure the compensation for the CEO from firm i, and $SIZE_i$ measures firm i's size (market cap). How does the omission of managerial ability from the above model affect the coefficient estimate $\widehat{\beta}_1$?

(g) (7 points) Outline the steps you would take to do cross-validation for a decision-tree model that predicts house prices using house characteristics.

2. (10 points) In a study published in the Journal of Finance, Lucca and Moench (2015) find that U.S. equities earn large excess returns in anticipation of monetary policy decisions made at scheduled meetings of the Federal Open Market Committee. Design a study to check whether this claim is indeed true in the data. Explain all the steps and specify what data you would need.

3. (20 points) **An interest rate model with stochastic volatility**

Suppose you observe two time series, the interest rates Y_t and unemployment rate X_t. You have a model for Y_t:

$$Y_{t+1} = \rho Y_t + (a_0 + a_1 X_t)\,\epsilon_{t+1},\ t = 1, ..., T$$

where $\epsilon_{t+1} \sim \mathcal{N}(0, 1)$ and are independent of the shocks to unemployment X_t and the lagged values of Y_t. There is no model for X_t.

(a) Show that it is valid to estimate ρ using an OLS regression of Y_{t+1} on Y_t.

(b) Suppose that the variance of the estimator $\widehat{\rho}$ is $(1/T)\sigma_\rho^2$. Describe how you would test the hypothesis that $\rho = 0$.

(c) Write down the conditional log-likelihood function of interest rates:

$$\mathcal{L}(Y_2, \cdots, Y_T | Y_1, \rho, a_0, a_1)$$

(d) Suppose that the parameters a_0 and a_1 are known. Derive the maximum-likelihood estimate for ρ.

4. (10 points) The following is an excerpt from a Bloomberg article in 2017:

> *"It's been said that the stock-picker's market is back ... Equity correlations plunged to a record low, as economic and policy optimism drew distinct leadership on U.S. exchanges. It was a welcome development for fund managers, whose efforts to pick winners [and beat their benchmarks] have been thwarted for years as shares swung in unison."*

The purpose of this question is to more rigorously examine the above statement.

(a) Interpret the statement. Specifically, if the statement is true, when is an active manager (who does stock-picking) more likely to out-perform the market — when the average correlation among stocks is high or low?

(b) Next, you want to do your own investigation. You have the data of quarterly returns for a group of active managers and the returns of the market index from 1991 to 2015. In addition, you have individual returns of all publicly traded stocks during the same period. List the steps to rigorously assess whether the statement above is true or not.
(**Hint:** You might need a way to measure how high equity correlation is in a particular year. For this you can use the cross-sectional standard deviation of returns across all stocks in that year. Suppose there are N stocks,

$$V_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(r_{it} - \bar{r}_t)^2}, \quad \bar{r}_t = \frac{1}{N}\sum_{i=1}^{N} r_{it}$$

Intuitively, if returns across stocks are highly correlated, their values should be closer to each other, leading to lower V_t.)

Extra space