

FE 535: Introduction to Financial Risk Management

Exam II

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Instructions

1. The exam is due Thursday at **11:59 PM May 9th, 2024**.
2. The exam consists of
 - 26 multiple choice questions.
 - 1 multiple choice bonus question.
 - Two open-ended questions. Required data is available in the excel sheets distributed with this test.
3. No hand-written answers will be accepted. Submit both a pdf of your answers and a copy of the completed excel sheet. Submit both documents strictly on the cavas portal - no submission via email attachment is accepted. Please show all your work on your submitted pdf document to earn full credit or partial credit. The multiple choice questions should be submitted on the first worksheet of the submitted excel sheet. Simply enter your answer choices in the appropriate field.
4. The computations should be conducted using Excel only. No need for coding. Answers completed in R or Python will not be accepted
5. As this is a final exam, a strict late policy will be implemented. One percentage point will be deducted for every minute the exam is submitted late.

Good Luck!

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Multiple-Choice Questions (65% Percent, 2.5 pts each)

1. An investor has a bond portfolio worth USD 20,000 with a duration of 8. How can the position be hedged with a bond that has a duration of 10 years?

Note: By *hedged*, the question refers to attaining a zero-duration target.

- (a) Short USD 20,000 of the bond with a duration of ten
 - (b) Short USD 16,000 of the bond with a duration of ten
 - (c) Long USD 20,000 of the bond with a duration of ten
 - (d) Short USD 12,000 of the bond with a duration of 10
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2. A manager wants to swap a bond for a bond with the same price but a higher duration. Which of the following bond characteristics would be associated with a higher duration?

- (a) A lower coupon rate with a shorter term to maturity
 - (b) A lower coupon rate with a longer term to maturity
 - (c) A higher coupon rate with less frequent payment
 - (d) A higher coupon rate with more frequent payment
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3. How would you rank the bonds from the shortest to the longest duration?

Bond Number	Maturity (Years)	Coupon Rate	Frequency	Yield (Annual)
1	10	6.00%	1	6.00%
2	10	6.00%	2	6.00%
3	10	0.00%	1	6.00%
4	9	0.00%	2	6.00%

- (a) 2-3-4-1
- (b) 2-1-4-3
- (c) 4-1-2-3
- (d) 4-2-3-1

4. Which of the following would be considered a key difference between a forward contract and a futures contract?

- (a) One clearinghouse is the counterparty to all forward contracts.
 - (b) The owner of the forward contract receives cash flows from the underlying asset between contract origination and delivery.
 - (c) Futures contract is marked to market regularly, while a forward contract is not.
 - (d) Only forward contracts can be set up as cash settlement contracts.
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5. Which of the following is incorrect regarding establishing central counterparties (CCPs)?

- (a) CCPs allow netting of contracts.
 - (b) CCPs can not be applied to OTC trades.
 - (c) CCPs can create more transparency in trading.
 - (d) CCPs mitigate counterparty risk in the financial system.
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6. Which one of the following statements is **incorrect** regarding the margining of exchange-traded futures contracts?

- (a) If an investor fails to deposit variation margin in a timely manner, the positions may be liquidated by the carrying broker.
- (b) Initial margin is the amount of money that must be deposited when a futures contract is opened.
- (c) A margin call will be issued if the investor's margin account balance drops below the maintenance level.
- (d) A margin call will be issued only if the investor's margin account becomes negative

7. A three-month forward contract on a stock index is trading at \$995. The current index level is \$980. Assume a continuously compounded interest rate of 5%. Additionally, assume that the stock index does not pay any dividends. Which one of the following statements reflects a potential arbitrage strategy:

- (a) Long the forward contract, short the stock index, and lend at the risk-free rate
- (b) Short the stock index and lend at the risk-free rate while entering a forward contract agreement to purchase the asset in three months for \$995.
- (c) Short the forward contract, borrow money at the risk-free rate, and long the asset.
- (d) None of the above

8. The potential arbitrage profit in Question 7 is:

- (a) \$0.000
- (b) \$2.512
- (c) \$2.673
- (d) \$2.723

9. The spot price of a stock is $S_0 = \$120$, and it is known that pays a quarterly dividend of $D = \$0.60$, the first and second payments are due in three and six months, respectively. What is the no-arbitrage price for a forward contract on this stock maturing in six months from now? The risk-free rate is $r = 5\%$. Choose the best answer.

- (a) \$153.130
 - (b) \$133.521
 - (c) \$121.820
 - (d) \$91.145
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10. Recall that the risk-neutral probability of an asset corresponds to the probability for which the expected return on the asset equals the risk-free rate. Consider a special case where the current asset value is $S_0 = 100$, and the annual risk-free rate is $r = 0\%$. The asset does not pay dividends. Additionally, consider a simple distribution in which the asset price goes up by \$10 with probability p and drops by \$10 with probability $1 - p$. Based on this information, what is the risk-neutral probability?

- (a) 0.55
 - (b) 0.50
 - (c) 0.45
 - (d) 1.00
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11. Consider the same information from the previous question. The price of a six-months forward contract is \$100. What is the potential arbitrage profit?

- (a) \$1.00
 - (b) \$0.00
 - (c) \$0.50
 - (d) -\$0.50
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The following information corresponds to Questions 12 and 13

An investor enters a short position in the S&P 500 E-mini futures contract that will expire in three months. The S&P 500 index currently trades at $S_t = \$4,538.43$. (As of 3-Dec-21.) Regarding contract specifications, the contract corresponds to 50 times the S&P 500 index. Additionally, the initial and maintenance margins are, respectively, \$12,100 and \$11,000. Finally, the futures contract is currently trading at $F_t(T) = \$4,531.25$ (actual settlement price for the Mar-22 contract on 3-Dec-21). Given this information, address the following two questions.

12. Suppose that the annual dividend yield is $q = 2\%$, what is the implied annual risk-free rate r ?

- (a) -0.012
- (b) 0.012
- (c) 0.014
- (d) -0.0370

13. Which of the following scenarios would lead to a margin call?

- (a) The next day futures price drops to \$4,416.33
 - (b) The next day futures price increases to \$4,560.33
 - (c) The next day futures price drops to \$4,516.53
 - (d) The next day futures price increases to \$4,550.55
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14. Pear, Inc. is a manufacturer that is heavily dependent on plastic parts shipped from Malaysia. Pear wants to hedge its exposure to plastic price shocks over the next 6 months. Futures contracts, however, are not readily available for plastic. After some research, Pear identifies futures contracts on other commodities whose prices are closely correlated to plastic prices. Futures on Commodity A have a correlation of 0.70 with the price of plastic, and futures on Commodity B have a correlation of 0.80. The price of plastic Futures on both Commodity A and Commodity B are available with 6-month and 9-month expiration. Ignoring liquidity considerations, which contract would be the best to minimize basis risk?

- (a) Futures on Commodity A with 6 months to expiration
 - (b) Futures on Commodity B with 6 months to expiration
 - (c) Futures on Commodity A with 9 months to expiration
 - (d) Futures on Commodity B with 9 months to expiration
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15. Victor Lu is the fixed income manager of a large Canadian pension fund. The present value of the pension fund's portfolio of assets is CAD 4 billion while the expected present value of the fund's liabilities is CAD 5 billion. The respective modified durations are 9.254 and 6.825 years. The fund currently has an actuarial deficit (assets < liabilities) and Victor must avoid widening this gap. There are currently two scenarios for the yield curve: The first scenario is a downward shift of 25bp, with the second scenario an upward shift of 25bp. The most liquid interest rate futures contract has a present value of CAD 68,336 and a duration of 2.1468 years. Analyzing both scenarios separately, what should Victor do to avoid widening the pension fund gap? Choose the best answer.

	Scenario 1	Scenario 2
(a)	Short futures	Long futures
(b)	Long futures	Short futures
(c)	Short futures	Short futures
(d)	Long futures	Long futures

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16. According to the CME Group, the market price of the E-mini futures is \$2,939.25. Each futures contract delivers 50 times the index. A long-only equity portfolio with a market value of USD \$10,000,000 has a beta of 1.25. The portfolio manager is planning to increase market exposure such that the portfolio beta becomes 2.25. How many futures contracts should the manager long/short?
- (a) Short 68
 - (b) Long 68
 - (c) Short 51
 - (d) Long 51
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17. The purpose of computing a minimum variance hedge ratio is to minimize the variance of the:
- (a) hedging instrument.
 - (b) correlation estimator.
 - (c) instrument to be hedged.
 - (d) combined underlying and hedging instrument portfolio.
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18. Today, the spot price of the EUR/USD exchange rate is \$1.0796. The bid and ask quotes for the nine-month EUR/USD forward contracts are, respectively, 73.56 and 75.68. According to the interest rate parity, what is the implied foreign interest rate differential?

Recall that quotes are reported in basis points, which is the common practice in the FX market.

- (a) 0.92%
- (b) 0.51%
- (c) 1.37%
- (d) 2.73%

The following information corresponds to Question 19 and 20.

An airline company knows that it will need to purchase 5,000 metric tons of jet fuel in three months. It seeks protection against an upturn in prices using futures contracts. As there is no futures contract on jet fuel, the company refers to heating oil instead. The company can hedge using heating oil futures contracts traded on NYME and the notional for one contract is 42,000 gallons. The current price of jet fuel is \$277/metric ton. The futures price of heating oil is \$0.6903/gallon. Additionally, you are given the regression results below.

Linear Regression Results for Airline Risk Management

The dependent variable (Y) is the quarterly return on jet fuel price, while the independent variable (X) is the quarterly return on the heating oil futures contract. The table below summarizes the results of a linear regression $Y = \alpha + \beta X + \epsilon$, which covers estimates, standard errors, and other statistics. The numbers in the parenthesis denote the standard error of the estimate. For instance, 0.007 denotes the estimated intercept $\hat{\alpha} = 0.007$, whereas 0.0101 below it corresponds to the standard error of this estimate.

	<i>Dependent variable:</i>
	Jet Fuel
$\hat{\alpha}$	0.007 (0.016)
$\hat{\beta}$	1.065*** (0.101)
Observations	20
R ²	0.862
Adjusted R ²	0.854
Residual Std. Error	0.070 (df = 18)
F Statistic	111.980*** (df = 1; 18)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01

19. How many futures contracts does the airline company need to long/short?

- (a) Long 117 contracts
- (b) Long 51 contracts
- (c) Short 90 contracts
- (d) Long 90 contracts

20. What is the standard deviation of the hedged fuel cost in dollars?

- (a) \$15.3K
 - (b) \$94.6K
 - (c) \$11.2K
 - (d) \$82.2K
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21. Firms commonly incentivize their management to increase the firm's value by granting managers securities tied to the firm's stock. Some securities, however, can reduce managerial incentives to manage risk within the firm. Among the following scenarios, which is likely the best example of this type of security?

- (a) Deep out-of-the-money call option on the firm's stock
 - (b) Deep-in-the-money call option on the firm's stock
 - (c) At-the-money call option on the firm's stock
 - (d) Long position in the firm's stock
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22. According to put-call parity, shorting a call option on a stock while longing a put option with the same maturity and strike price is equivalent to:

- (a) Buying a put option, selling the stock, and investing the proceeds at the risk-free rate.
 - (b) Buying a put option and buying the stock with funds borrowed at the risk-free rate.
 - (c) Longing a forward contract.
 - (d) Shorting a forward contract.
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23. A trader can close a long position in a put option by:

- (a) longing a put.
 - (b) shorting a call.
 - (c) shorting a put.
 - (d) longing a call.
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24. What will be the lower bound for the price of a three-month European put option on a non-dividend-paying stock if the current stock price is USD 22, the strike price is USD 26, and the annual risk-free rate is 10%? Choose the best answer.

- (a) \$3.36
 - (b) \$4.00
 - (c) \$2.69
 - (d) \$4.83
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25. The current price of stock ABC is \$98 and the put option with a strike at \$100 is trading at \$6.34. Expiration is in one year. The corresponding call is priced at \$8.22. Which of the following trading strategies will result in arbitrage profits? Assume that the annual risk-free rate is 5%, and that there is a risk-free bond paying the risk-free rate. At the same time, assume that there are no transaction costs.

- (a) Long position in both the call option and the risk-free bond, and short position in the stock and the put option
 - (b) Short position in both the call option and the stock, and long position in the put option and risk-free bond
 - (c) Short position in both the call option and the put option, and long position in the stock and risk-free bond
 - (d) Long position in both the call option and risk-free bond, while longing the stock and the put option
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26. To create a delta-neutral portfolio, the SIT fund has sold 10,000 at-the-money (ATM) put options on Epsilon stock with when the shares were trading at \$100. The risk manager from SIT uses the Black-Scholes model to value all option exposures. The current price of the shares is \$90. The annualized standard deviation of Epsilon stock returns is 40% and the option expires in six months. If the risk-free rate is 2%, approximately, what is the likelihood that this option will be exercised?

- (a) 0.6839
- (b) 0.7975
- (c) 0.3161
- (d) 0.2025

27. **BONUS 5pt** A bank has a \$200,000 loan outstanding. The bank estimates that its expected credit loss is \$1120, and that the loss given default is a uniform random number between 60% and 80%. Find the unexpected loss from the position.

- (a) \$13,694.72
- (b) \$12,725.78
- (c) \$14,170.39
- (d) \$15,074.01

Open-Ended Questions (35% Percent)

Question 1: Bond Fundamentals

A 10-year fixed-coupon bond is paying a \$4 coupon annually. Suppose that the bond's yield is 5% and the face value is \$100. Let $P_t(T)$ denote the price of a bond at time t maturing at year T . Given this information, address the following:

1. Compute the bond price at time $t = 0$, i.e., $P_0(10)$.

Hint: to confirm your answer is correct, compute the discounted cash flows manually using the Excel spreadsheet (tab named “Bond_Price”).

2. Five year pass, and the interest rate remain unchanged. Assuming a flat term structure and holding all other factors constant, compute $P_5(10)$, i.e., the bond price at the beginning of year five after receiving the fifth coupon payment.
3. Using Excel and the pricing equation for a fixed-coupon bond, you need to plot the price of this bond over time. In other words, compute $P_t(10)$ for $t = 0, 1, 2, \dots, 10$. As a summary, you need to attach an image file via the Google form.
4. **Discussion:** The above discussion ignores credit risk, i.e., we assume that the coupons and face value are paid with 100% probability over the 10-years period. Suppose instead that there is always a positive chance of not receiving such cash flows. What would happen to the plot from the previous question? **Explain briefly.**

Question 2: Option Pricing

The following questions correspond to the data excel file named `Exam_II_Data.xlsx` - see instructions. The file covers 1000 simulated paths for a Geometric Brownian motion under risk-neutral valuation. Each path corresponds to 12 simulated monthly stock prices. In all cases, the initial price is set to $S_0 = \$400$ and the risk-free rate is $r = 5\%$. Based on this information, address the following:

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1. Given the 1000 simulated paths, calibrate the annual stock volatility.

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2. Given the 1000 simulated paths, calibrate the annual mean return.

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3. Consider a **European call** option expiring in **nine months** from now. The strike price is $K = \$450$. Using the Black-Scholes model, what is the price of this option?

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4. Consider the same **European call** option from the previous question. Given the 1000 simulated paths, what is the estimated price of this option?

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5. Given the 1000 simulated paths, what is the 95% Value-at-Risk (VaR) of position that longs such **European call** option?

Note: The $1 - \alpha$ VaR is computed as

$$VaR_t(X_T, \alpha) = e^{-r(T-t)} [\mathbb{E}_t[X_T] - Q_t(X_T, \alpha)] \quad (1)$$

where X_T denoting the PnL at time T and $Q_t(X_T, \alpha)$ is the α -percentile of the PnL.

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6. Related to the previous question, suppose instead you take a short position in this **European call** option. What is the 95% VaR of such position?
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7. Suppose instead you take a long position in this **European call** option while taking a short position in a **European put** option with the same maturity and strike price. What is the 95% VaR of this position?
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Knock-In Barrier Option

Consider a specific exotic option known as Knock-In (KI) Barrier option. This option is similar to a European option, whereas the main difference is that it only gets *activated* if the stock price reaches a specific barrier denoted by U during the option's life. Specifically, if the price at any point of time goes above U , the option becomes a European option and remains in existence until maturity. Otherwise, it expires worthless.

8. Suppose that $U = \$500$, what is the price of **knock-in barrier call option** expiring in **nine months** with strike $K = \$450$? You need to price this option using the simulated prices.
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9. How does the price of this exotic option (Question 8) compare with that of the European call option (Question 4)? Explain briefly.