SOCIETY OF ACTUARIES

Quantitative Finance and Investment Portfolio Management Exam

Exam QFIPM

Date: Wednesday, October 28, 2020

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 16 questions numbered 1 through 16 with a total of 100 points.

   The points for each question are indicated at the beginning of the question.

2. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions provided in this document.

Written-Answer Instructions

1. Each question part or subpart should be answered either in the Word document or the Excel file as directed. Graders will only look at work in the indicated file.

   a) In the Word document, answers should be entered in the box marked ANSWER. The box will expand as lines of text are added. There is no need to use special characters or subscripts (though they may be used). For example, β_1 can be typed as beta_1 (and ^ used to indicate a superscript).

   b) In the Excel document formulas should be entered. Performing calculations on scratch paper or with a calculator and then entering the answer in the cell will not earn full credit. Formatting of cells or rounding is not required for credit.

   c) Individual exams may provide additional directions that apply throughout the exam or to individual items.

2. The answer should be confined to the question as set.

3. The Word and Excel files that contain your answers must be uploaded before time expires.

Recognized by the Canadian Institute of Actuaries.

For this exam all answers are to be provided in Word. Excel is available as a calculation tool if candidates are so inclined, but graders will not look at their Excel file.

For purposes of this question, use notation that is easy to type. No credit will be taken away for simplified notation, i.e. subscripts such as R_A can be written as RA.

1. (*7 points*) Company ABC manages its defined benefit pension plan by an asset-liability management approach, focusing on the pension plan surplus (defined as assets minus liabilities). A simple one-period static model is used to model the liabilities return as follows:

$$R_{L,t} = R_{f,t} + \beta\left(R_{B,t} - R_{f,t}\right) + \varepsilon_t$$

where:

$R_{L,t}$ = Expected annual return on the liability at time *t*

$R_{f,t}$ = Annual risk-free rate of return of at time *t*

$R_{B,t}$ = Expected annual return of bond index XYZ at time *t*

ε_t = Normally distributed noise term at time *t*

You are given the following information on Company ABC's pension assets and liabilities on December 31st, 2019:

- There is no asset that is negatively correlated with the (liability) noise
- The risk-free interest rate = 1.5%
- The annual mean and standard deviation of ε_t is 0% and 2%, respectively
- The pension liabilities duration = 12 years
- The pension asset data is shown below

Asset class	Allocation	Expected annual return	Annual standard deviation	Duration
U.S. equity	30%	10.0%	15.0%	n/a
Global equity	30%	8.0%	14.0%	n/a
Bond index XYZ	20%	5.0%	8.0%	11.5
U.S. treasury	20%	3.5%	5.0%	10.0

1. Continued

(a) (*0.5 points*) Calculate the expected return of the pension liabilities as of December 31st, 2019.

ANSWER:

(b) (*1 point*) Explain sources of uncertainty in pension liabilities captured by the term ε_t.

ANSWER:

The company sponsor is considering making a large contribution to the Pension Fund that would more than cover the future cost of the liabilities.

(c) (*0.5 points*) Describe the least risky investment strategy to fund the pension liability.

ANSWER:

(d) (*0.5 points*) Determine the strategy's expected surplus volatility.

ANSWER:

On December 31st, 2019, Company ABC's pension plan funding ratio was 0.9 and the company expected a 0% payout in year 2020.

(e) (*2 points*) Calculate the following as of December 31st, 2019:

(i) The expected funding ratio on December 31st, 2020, using a return on surplus $R_x = 1.85\%$

(ii) The maximum payout structure *p* that the pension fund can sustain in year 2020 while maintaining its current funding ratio on December 31st, 2020.

ANSWER:

1. Continued

You evaluate a subset the pension liabilities by using the risk-free interest rate as the liability discount rate. Assume that the pension plan future cashflows are equivalent to a single payment amount that is due 20 years from today. You have been provided a scenario for one month from today:

- A shock in the actuarial assumptions will increase the single payment amount by 5%
- The risk-free interest rate is expected to decrease by 10 basis points.

(f) (*1 point*) Estimate the expected percentage change in the liability value one month from today under the above scenario.

ANSWER:

After working three years as a pension fund manager at company ABC, you are approached by an actuarial recruiter with an opportunity to join the ALM team at a life insurance company.

(g) (*1.5 points*) Compare and contrast the managing of a defined benefit pension plan vs. a life insurance fund.

ANSWER:

2. (*7 points*) You are an actuary working for the CFO of XYZ Insurance Company. XYZ has substantial liability payments in 6 years and is interested in commercial real estate investments.

The CFO told you that within the commercial mortgage industry an important division occurs between two types of mortgage loans from the point of view of the loan's purpose.

(a) (*1 point*) Compare and contrast the default and interest rate risks of these two main types of mortgage loans.

ANSWER:

XYZ is considering allocating a significant portion of its portfolio into one of the following two CMBS: CMBS-I and CMBS-II.

	CMBS-I	CMBS-II
Tranche A (investment grade)	\$200M par value 5% coupon rate	\$220M par value 5% coupon rate
Tranche B (below-investment grade)	\$50M par value 8% coupon rate	\$80M par value 8% coupon rate
Tranche X (interest only)	\$250M notional par 1.4% coupon rate first 4 years, 1.0% coupon rate thereafter	\$300M notional par 1.5% coupon rate first 7 years, 1.1% thereafter
Frequency of coupon payments	Annual, payable in arrears	Annual, payable in arrears
Mortgages backing the CMBS	A pool of 5 mortgages, with 2 maturing in 4 years, and 3 maturing in 6 years: • Each with \$50M loan balance and the same coupon rate • Mortgages are Interest-Only with all principal payable on maturity	A pool of 3 mortgages, with 1 maturing in 7 years, and 2 maturing in 10 years: • Each with \$100M loan balance and the same coupon rate • Mortgages are Interest-Only, with all principal payable on maturity
Total market value of the underlying properties	\$400M	\$450M

2. Continued

(b) (*2 points*) Recommend which CMBS to purchase based on:

(i) Loan-to-Value ratio

(ii) Weighted Average Maturity

ANSWER:

XYZ decided to purchase a 50% share in Tranche A of CMBS-I for $100M. There was no default in the first 4 years.

(c) (*1 point*) Calculate the subordination of Tranche A at the beginning of Year 5.

ANSWER:

2. Continued

At the beginning of Year 6 the 3 remaining mortgages have not defaulted, the market value of XYZ's remaining holding in CMBS-I is $48M. You believe there are two possible scenarios regarding the underlying mortgages of CMBS-I:

- Scenario 1 (60% probability): Two mortgages default during the year, with the CMBS servicer being able to recover a total amount of $45M in respect of these two mortgages at the end of Year 6. The remaining mortgage is paid off as expected at the end of Year 6.
- Scenario 2 (40% probability): All mortgages are paid off on schedule.

The CFO is considering two action plans at the beginning of Year 6:

- Plan A: Hold CMBS-I to maturity. Assume all principal and interest payments collected on the mortgages are fully distributed to CMBS holders, i.e. there are no fees, servicing costs or other expenses.
- Plan B: Sell all CMBS-I at market value and reinvest the proceeds in a 1 Year Treasury Bill with 2.5% annual return. Assume there are no additional expenses and no default or tax impact.

(d) (*3 points*) Recommend which action plan to take based on the expected Holding Period Return in Year 6.

ANSWER:

3. (*7 points*) You work for insurance company ABC, which has a significant amount of assets under management and expertise in investing in leveraged loans. You are looking to sell leveraged loans on the secondary market via either assignment or participation. Your company and the prospective buyers are on good terms with the borrowers. Your company is looking to achieve the best price on the sale.

(a) (*1 point*) Recommend how the company should seek to sell the loans via assignment or participation.

ANSWER:

The CIO likes the fundamentals of leveraged loans and believes the company has a competitive advantage in identifying attractive deals in leveraged loans, but feels that regulatory required capital requirements are too high relative to other asset classes. ABC does not calculate economic capital. The CIO asked you to explore alternative asset classes including CLOs and High Yield Bonds.

(b) (*1 point*) Explain two ways by which the creation of a CLO would likely add value for ABC.

ANSWER:

A colleague states: "Though the equity tranche is at the bottom of the capital structure of a CLO, it is not as risky as it seems. In the case of bankruptcy, the absolute priority rule is often violated, therefore the equity tranche is likely to receive some payment before the senior tranches are paid in full."

(c) (*1 point*) Critique your colleague's statement regarding CLOs.

ANSWER:

3. Continued

The CIO has supplemented the company's investment in leveraged loans with an allocation to high yield bonds. The CIO is concerned about the company's interests in the event the borrower's financial condition deteriorates. Your colleague has suggested researching the following characteristics of high yield bonds:

- Put provisions
- Call protection
- Bullet structure
- Equity warrants

(d) (*2 points*) Explain whether each characteristic would address the CIO's concern.

ANSWER:

The CIO is considering the three following asset classes:

- Leveraged Loans
- Senior Tranche CLOs
- High Yield Bonds

The CIO states the following:

- "Credit risk is attractively priced and we should maintain exposure to credit risk."
- "To duration match the liabilities, we should invest in fixed-rate assets with as long maturities as possible."
- "We have a competitive advantage in navigating bankruptcies to maximize recovery rates."

(e) (*2 points*)

(i) (*1.5 points*) Assess whether each of the three asset classes is appropriate in the context of each the above statements.

(ii) (*0.5 points*) Recommend one of the above three asset classes.

ANSWER:

4. (*6 points*) B Corp and L Bank are considering entering into the following interest rate swap:

- Notional Amount: 100 million
- Maturity: 1 year
- Payer: B Corp pays fixed rate of 4% per annum
- Receiver: L Bank pays floating rate of 1 year LIBOR + 1% per annum observed at the end of the year
- Frequency: Payment made at the end of the year
- Original Cost: $0

(a) (*2 points*) Describe the dynamic credit exposure created by this transaction for each of the two swap counterparties.

ANSWER:

(b) (*1 point*) Determine a value of LIBOR at the end of the year which results in positive credit exposure from this transaction, for each of:

(i) B Corp

(ii) L Bank

ANSWER:

(c) (*1 point*) Calculate the resulting credit exposure for each party at the end of the year, under each of the two LIBOR values determined in part (b), to complete the table below:

	End-of-Year Credit Exposure	
Party	LIBOR from b(i)	LIBOR from b(ii)
B Corp		
L Bank		

ANSWER:

4. Continued

In order to assign a gross exposure amount to the interest rate swap, the credit risk manager of L Bank is planning to use a one-year value-at-risk (VaR) at a 99.5% confidence level, from the distribution of possible mark-to-market (MTM) values.

(d) (*1.5 points*) Describe in words a graph for the probability density for L Bank's MTM value for this transaction, covering the following elements:

(i) Description of the x (horizontal) and y (vertical) axes

(ii) Interpretation of the area below the curve

(iii) Description of general shape that might be expected

(iv) Explanation of where L Bank's gross exposure (VaR at 99.5%) would lie on that graph, and

(v) Explanation of where higher and lower LIBOR rates would be represented on the graph

ANSWER:

(e) (*0.5 points*) Outline reasons why L Bank might want to consider using VaR at 99% instead of VaR at 99.5% for determining its gross exposure amount.

ANSWER:

5. (*5 points*) You are a retail investor working with a financial advisor who actively manages your retirement portfolio. The price of one of your equity holdings, AAA, has dropped to $18 since your financial advisor purchased it at $20 a week ago. You searched for news on AAA but found nothing notable. Getting worried, you discussed this with your advisor and he recommended:

"I wouldn't sell now to realize the losses. AAA has never dropped more than 20% over three months. I analyzed their business model extensively when I bought their shares for another client's portfolio five years ago. Same business today. It's a fantastic name to keep holding."

(a) (*2 points*) Describe three behavioral biases your advisor may be displaying.

ANSWER:

(b) (*1 point*) Explain how the behavior biases of institutional investors could have contributed to AAA's rapid price change.

ANSWER:

Your retirement portfolio is meant to be globally diversified, but you noticed your advisor has a strong home country bias and invested only in US securities.

	Return
Your Manager	10%
MSCI World Index	8%
MSCI US Index	15%

- The portfolio's total active risk computed with respect to MSCI World Index is 6% annually.
- Your manager's true risk adjusted performance (information ratio) is -1.118.

(c) (*2 points*) Calculate your manager's misfit risk.

ANSWER:

6. (*5 points*) You are evaluating XYZ ALM process during which you observe the following:

- XYZ's assets include treasuries, corporate bonds, commercial mortgages and MBS, and a small portion of equities.
- XYZ calculates and reports the effective durations of liabilities and assets quarterly. For the most recent quarter, the asset duration is 15 years and the liability duration is 33 years.
- XYZ liabilities consist of products that have policy holder options and guarantees.
- Below are sensitivity results from XYZ's ALM model:

Interest Rate Move	Asset	Liability
Shock Up 50 bps	180M	160M
No Shocks	200M	180M
Shock Down 50 bps	210M	220M

(a) (*1 point*) Define in words:

(i) Macaulay duration

(ii) Effective duration

(iii) Dollar duration

(iv) Partial duration

ANSWER:

(b) (*1 point*) Explain four reasons that the value of the assets could move differently from the effective duration predicted value.

ANSWER:

6. Continued

(c) (*1 point*) Identify two risks that XYZ faces in a falling interest rate environment.

ANSWER:

Your assistant reviewed XYZ's ALM policy along with current economic conditions and made the following suggestions:

- In the current low interest rate environment, the company should lower the allocation in bonds and increase allocation to equities to boost investment earnings.
- With a nearly flat yield curve, the company should reduce the duration of the assets to stay liquid in case interest rates spike up.
- The company should invest in emerging market debt because it achieved a high rate of return last year.

(d) (*2 points*) Critique your assistant's suggestions.

ANSWER:

7. (*5 points*) You are an investment actuary at ABC Insurance, a medium-sized life insurance company specializing in universal life and long-term care products. You are part of a new team responsible for modernizing ABC's investment strategy. ABC has invested exclusively in corporate bonds with very high credit ratings but is now looking to diversify their portfolio.

You are at a meeting with your team when your supervisor asks for recommendations for asset classes that ABC could invest in. An analyst suggests investing in infrastructure, which prompts discussion among the team.

Listening to the discussion, your supervisor reminds the team of ABC's requested investment characteristics for any new asset, which include:

- Hedge against inflation
- Liquidity
- Low correlation with other asset classes
- Lack of regulatory risk
- Attractive returns
- Long duration

(a) (*1.5 points*) Explain whether or not the infrastructure asset class satisfies each of ABC's requested investment characteristics.

ANSWER:

Another team member argues against investing in infrastructure assets. He claims that infrastructure investments are too risky.

(b) (*1 point*) Describe 4 key risks associated with infrastructure projects and companies.

ANSWER:

He also states that it's difficult to reliably benchmark the performance of infrastructure.

(c) (*1 point)* Describe 4 possible methods for benchmarking infrastructure assets.

ANSWER:

7. Continued

(d) (*1.5 points*) Recommend whether or not ABC should invest in the infrastructure asset class.

ANSWER:

8. (*7 points*) You are the portfolio manager responsible for managing the investment portfolio for an insurance company, focusing on bonds and equities. Your chief risk officer (CRO) wants to diversify the portfolio by adding alternative investments. She is interested in two types of hedge fund investment: Hedged equity and Fund of funds.

(a) (*1.5 points*) Describe:

(i) (*0.5 points*) key features of these two types of hedge fund investments

(ii) (*1 point*) the potential concern of the survivorship bias for investors in them

ANSWER:

Your colleague proposes to use managed futures rather than hedge funds for the following reasons:

1. Unlike hedge funds, which are only available to accredited investors, managed futures are open to broader range of investors and hence are considered to be more liquid.
2. Compensation arrangements tend to be less expensive for managed futures than hedge funds.
3. Managed futures focus on broader macro equity and bond markets whereas hedge funds look for inefficiencies in micro levels of equity and bond markets, so managed futures are easier to trade.
4. Managed futures are very active in spot markets whereas hedge funds mostly trade in derivative markets for hedging purposes.
5. Managed futures are usually less regulated than hedge funds.

(b) (*2 points*) Critique your colleague's proposal and the reasons given.

ANSWER:

8. Continued

Your CRO has drafted an investment objective for adding investments to the existing portfolio, which is to maximize the Sharpe ratio and expect to achieve consistent positive returns. She asked you to use the following information and provide her a recommendation:

	Portfolio A: Current Portfolio	Hedge Fund	Managed Futures	Portfolio B: 90% Portfolio A +10% Hedge Fund	Portfolio C: 90% Portfolio A +10% Managed Futures
Expected return	6%	12%	9%		
Std. dev. of return	12%			10%	9%
Skewness of return	-1			-0.9	0.3

- Risk-free interest rate is 3.6%;

(c) (*2 points*) Recommend a portfolio from the table above based on her drafted investment objective.

ANSWER:

As part of the due diligence, you mention to your CRO that the Sharpe ratio may not be a good performance assessment measure as it has a number of limitations. One limitation is that the reported Sharpe ratio can be artificially increased without the investment delivering higher risk-adjusted returns.

(d) (*1.5 points*) Describe three ways that the Sharpe ratio can be gamed.

ANSWER:

9. (*6 points*) You are the financial reporting actuary at ABC Life Insurance Company. You work closely with the finance and accounting department to analyze the impact of IFRS 9 and IFRS 17 for your company. ABC Life sells exclusively whole life insurance with a cash value component (which can be loaned against) and term life insurance with no cash value component. You are given the following assets and their respective allocation policies.

Class	Allocation Policy
Long-term secured government bonds	Backing liability and intend to hold to maturity
Long-term A-rated corporate bonds	Backing liability and intend to hold to maturity; often sell assets for financial gain
Exchange Traded Funds (Equity)	Backing liability, actively rebalanced to mitigate market risk
Vanilla ATM put option on S&P500	Not backing liability

(a) (*2 points*) Recommend the IFRS 9 accounting treatment that should be applied to each asset.

ANSWER:

(b) (*2 points*) Explain why there will be accounting mismatches between the financial results from the assets and liabilities for ABC Life in the context of IFRS 9 and IFRS 17.

ANSWER:

You are asked to join a committee to assess the liquidity risk to ABC Life of a pandemic scenario.

(c) (*2 points*) Describe the liquidity risk to which ABC Life is exposed under the applicable stress tests ABC Life should perform.

ANSWER:

10. (*5 points*) You are the new investment actuary for two clients. Client A is a wealthy couple who:

- wish to leave a large inheritance to their children and grandchildren,
- practice philanthropy during their lifetimes
- seek out the maximum return in all situations.

Client B is a life insurance company operating in the U.S. Neither client currently has an Investment Policy Statement (IPS) in place.

(a) (*1 point*) Outline the scope and purpose of an IPS.

ANSWER:

(b) (*1 point*) Compare and contrast IPS investment objectives between the two clients.

ANSWER:

(c) (*1 point*) Explain governance considerations to be included in the insurance company IPS.

ANSWER:

(d) (*2 points*) Compare and contrast investment constraints between the two clients.

ANSWER:

11. (*6 points*) You are an investment analyst at a large pension fund. To gauge investment performance, the fund sponsor proposed a benchmark to be in the top quartile of its peer group over the previous calendar year.

(a) (*2 points*) Evaluate the properties of the proposed benchmark in comparison to an ideal benchmark.

ANSWER:

Your colleague recommended an equity portfolio manager, XYZ Investment Management, who runs a U.S. large-cap value portfolio which returned 23.5% during the first three quarters of 2019. You have been provided the following information for the same time period:

Index	Return
Russell 1000 Value Index	21.7%
Russell 2000 Index	27.5%
Russell 3000 Index	25.2%

(b) (*0.5 points*) Calculate XYZ Investment Management's return due to both style and active management.

ANSWER:

(c) (*0.5 points*) Interpret your results for both style and active management.

ANSWER:

11. Continued

The plan sponsor is trying to decide between two equity portfolio managers, ABC Equities and DEF Equities, for the same mandate. ABC will produce on average annual value-added return of 1.5% over the benchmark, with variability of the excess returns of 2.24%. DEF is expected to produce a higher annual value-added return of 4%, but with variability of excess returns around 10%. The table below shows the probability of a manager outperforming a benchmark given various levels of investment skills.

	Information Ratio					
Years	*0.20*	*0.30*	*0.40*	*0.67*	*0.80*	*1.00*
1.0	58.39	62.97	66.46	75.57	79.18	85.39
5.0	68.62	75.65	82.55	94.02	96.87	98.37
10.0	74.56	83.68	90.07	98.52	99.35	99.89
20.0	82.07	92.12	97.23	99.68	99.98	99.99

(d) (*1.5 points*) Determine which manager has the lower chance of outperforming the benchmark.

ANSWER:

Your colleague recommends DEF Equities over ABC Equities, based only on ABC's lower annual value-added return when compared to DEF.

(e) (*1.5 points*) Explain the shortcomings of your colleague's recommendation.

ANSWER:

12. (*7 points*) You are a risk manager responsible for managing and monitoring liquidity risk at ABC Insurance Company. A market crisis has recently started in both the equity and credit markets.

Your Chief Risk Officer (CRO) is looking at trends in credit bond spreads and their relation to liquidity cost. The spreads are widening as the market crisis worsens.

(a) (*1 point*) Explain why a spread decomposition can be useful for your company.

ANSWER:

(b) (*1 point*) Recommend a derivative instrument that can be used to hedge market liquidity risk.

ANSWER:

Your CRO is looking at a new bond based on Liquidity Cost Score (LCS) where the trading department will be using bid-ask indications to derive the LCS.

(c) (*2 points*) Explain the limitations of bid-ask indications and possible ways to overcome them.

ANSWER:

The new bond being considered has very high trading volume. The CRO thinks that since the bond has a high trading volume, the liquidity risk must be lower.

(d) (*1 point*) Explain whether the CRO is correct or not.

ANSWER:

12. Continued

Your CRO is looking to add a new bond to the long-term portfolio so that she can decrease the LCS of the overall portfolio. Your CRO has given you a list of several different bonds from the same issuer. The data is incomplete. Bonds E and F are on-the-run issues while bonds G & H are off-the-run issues.

	Monthly Trading Volume ($M)	Age (Years)	Issue Size ($B)	Quoted?	Benchmark/Non-Benchmark
Bond E	16	2	60	Yes	Unknown
Bond F	16	4	50	Unknown	Yes
Bond G	16	2	60	Yes	Unknown
Bond H	8	6	60	Unknown	Yes

(e) (*2 points*) Recommend which one of the bonds to add to the existing portfolio.

ANSWER:

For purposes of this question, use notation that is easy to type. No credit will be taken away for simplified notation, i.e. subscripts such as p_u can be written as pu.

13. (*8 points*) You have been asked to build a credit risk model for a portfolio of 1000 residential mortgages.

You make the following working assumptions:

- Each mortgage has an exposure of $100,000
- Mortgages are not independent of each other
- All mortgages have similar risk of default
- The probability of default is expressed as p = p(Z), where Z is a random variable

You first decide to model defaults using a binomial-mixture model, where the default probability p(Z) = exp (Z) where Z is normally distributed with mean $\mu = \ln(1/40)$ and variance $\sigma^2 = \ln(4)$, so that $E[p(Z)] = \exp(\mu+\sigma^2/2)$.

(a) (*1 point*) Identify desired characteristics of the credit risk model that make the choice of p(Z) important.

ANSWER:

(b) (*2 points*) Calculate the following:

(i) Expected probability of default for a mortgage

(ii) Variance of the probability of default

(iii) Covariance between the number of defaults for any two mortgages

(iv) Variance of the number of defaults for the portfolio

ANSWER:

13. Continued

You then decide to explore beta-binomial mixture models for modeling the defaults in that portfolio. You have independently estimated that the probability of default for a mortgage is 10% and the default correlation between any two mortgages is 10%, and you want to calibrate your model based on these values. You also assume that the recovery rate is 0% upon default of a mortgage.

(c) (*2 points*) Calculate the amount of capital required to cover expected losses plus two 2 standard deviations above the expected losses due to default for the portfolio.

ANSWER:

(d) (*1 point*) Describe two limitations of binomial-mixture models.

ANSWER:

You decide to use the CreditRisk+ model described in Bolder. After some further analysis, you realize that your portfolio is not homogeneous, but can be logically divided into 3 main groups each having a different risk of defaults: Urban, Suburban and Rural. You assume that this classification explains 70% of the default probability, the rest being related to the general economic condition, and therefore set $w_1 = 30\%$. You are given the following additional information:

Group	Urban	Suburban	Rural
Expected Probability of Default	10%	12%	8%

The correlation factor between Suburban and Urban mortgages is 40%.

(e) (*2 points*) Calculate the correlation factor between Urban and Rural mortgages.

ANSWER:

For purposes of this question, use notation that is easy to type. Some examples are: rho for ρ, e for ϵ_i, Y1 for Y_1, and sqrt(x) for $\sqrt{x}$.

14. (*8 points*) You are modelling defaults for a bond portfolio consisting of 100 obligors. You decide to use a Gaussian threshold model, where:

- Y_i are latent variables defined by $Y_i = \sqrt{\rho}G + \sqrt{1-\rho}\,\epsilon_i$,
- G and ϵ_i are independent, identically distributed standard normal random variables,
- ϵ_i are independent, for all i, and
- $0 \le \rho \le 1$.

(a) (*1.5 points*) Derive the covariance matrix of $[Y_1, Y_2]$ by determining $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$, and identify their joint distribution

ANSWER:

You are given a default threshold K_i for each latent variable Y_i, where default occurs when Y is below the threshold K. You define:

- p_i as the unconditional probability of default for obligor i
- $p_i(G)$ as the probability of default for obligor i, conditional on G

(b) (*2 points*) Determine an expression for the values of G which will satisfy the condition $p_i < p_i(G)$, for a given value of ρ.

ANSWER:

(c) (*1.5 points*) Explain why the default correlation between obligors is different than the correlation between latent variables Y_i.

ANSWER:

14. Continued

You decide to change the latent variables to $X_i = \sqrt{\frac{v}{W}}\left(\sqrt{\rho}G + \sqrt{1-\rho}\,\epsilon_i\right)$, where W is a $\chi^2(v)$ independent random variable and $v > 2$ represents the degrees of freedom.

(d) (*1 point*) Describe advantages that a threshold model using X_i as latent variables has over the Gaussian threshold model using Y_i.

ANSWER:

You are given that the covariance between any two X_i is 20% and the expectation of 1/W is 0.0556.

(e) (*2 points*) Calculate the correlation between any two X_i.

ANSWER:

15. (*5 points*) You are reviewing the performance of the investment team in the company with three portfolio managers managing a $700 million portfolio. You are given the following summary information:

	Manager A	Manager B	Manager C	Benchmark
Assets under management ($ million)	200	100	400	
Number of stocks	30	20	95	100
Dividend yield	3%	5%	4%	4%
P/E ratio	7.1	3.0	4.9	5.0
P/B ratio	4.1	2.5	3.1	3.0
EPS growth (5-year projected)	17%	11%	15%	15%
Active return	2%	3%	0%	
Tracking risk	4%	5%	0%	

(a) (*1.5 points*) Evaluate the performance of each individual manager and overall portfolio based on the trade-off between active return and tracking risk.

ANSWER:

(b) (*1 point*) Evaluate the investment style and strategy of Manager B.

ANSWER:

(c) (*0.5 points*) Describe the structure of the overall portfolio.

ANSWER:

You wonder if the benchmark is a good indicator for the performance measurement and would like to find out more using either returns-based or holdings-based style analyses.

(d) (*2 points*) Compare and contrast these two analyses.

ANSWER:

16. (*6 points*) You work for ABC bank which is involved in fixed income securities trading. You purchased a Treasury note and plan to hold it for one day.

(a) (*1 point*)

(i) Explain how an overnight repurchase agreement works.

(ii) Explain why it would be a more cost efficient way to finance this purchase, instead of using the bank's own funds.

ANSWER:

(b) (*1.5 points*) Explain how two common practices are used to reduce credit risk in repurchase agreements.

ANSWER:

ABC bank also deals in Mortgage Backed Securities (MBS) and is considering a collateralized loan to cover a short position in their securities.

(c) (*1.5 points*)

(i) Describe a dollar roll transaction

(ii) Explain how it differs from repo agreement.

ANSWER:

16. Continued

ABC bank enters into an agreement in which it agrees to sell \$1 million par value of a MBS at $101\frac{7}{32}$ and repurchase substantial identical securities a month later at 101. The coupon rate for this MBS is 7%, paid monthly. The regular scheduled principal payment for the month is \$1,000 and assumed prepayment is projected to be \$3,000.

(d) (*2 points*) Calculate the financing cost of this transaction in terms of an annual rate.

ANSWER:

****END OF EXAMINATION****