Exam 9

Expertise. Insight. Solutions.

CASUALTY ACTUARIAL SOCIETY
AND THE
CANADIAN INSTITUTE OF ACTUARIES

Canadian Institute of Actuaries / Institut canadien des actuaires

Jeanne Crowell
Vice President-Admissions

Jason Russ
Chairperson
Syllabus & Examination Committee

Frances Sarrel
General Officer-Syllabus
Syllabus & Examination Committee

Exam 9

Financial Risk and Rate of Return

Syllabus & Examination Committee
General Officers
Christopher DiMartino
Michelle Iarkowski
Michael Larsen
Dustin Loeffler
Brian Mullen
Kathleen Odomirok
James Sandor
Thomas Struppeck
Rhonda Walker
Christopher Styrsky

May 3, 2019

4 HOURS

INSTRUCTIONS TO CANDIDATES

1. This 52.5-point examination consists of 19 problem and essay questions.

2. For the problem and essay questions, the number of points for each full question and part of a question is indicated at the beginning of the question or part. Answer these questions on the lined sheets provided in your Examination Envelope. Use dark pencil or ink. Do not use multiple colors or correction fluid/tape.

   - Write your Candidate ID number and the examination number, 9, at the top of each answer sheet. For your Candidate ID number, four boxes are provided corresponding to one box for each digit in your Candidate ID number. If your Candidate ID number is fewer than 4 digits, begin in the first box and do not include leading zeroes. Your name, or any other identifying mark, must not appear.
   - Do not answer more than one question on a single sheet of paper. Write only on the front lined side of the paper – **DO NOT WRITE ON THE BACK OF THE PAPER**. Be careful to give the number of the question you are answering on each sheet. If your response cannot be confined to one page, please use additional sheets of paper as necessary. Clearly mark the question number on each page of the response in addition to using a label such as "Page 1 of 2" on the first sheet of paper and then "Page 2 of 2" on the second sheet of paper.
   - The answer should be concise and confined to the question as posed. When a specified number of items are requested, do not offer more items than requested. For example, if you are requested to provide three items, only the first three responses will be graded.
   - In order to receive full credit or to maximize partial credit on mathematical and computational questions, you must clearly outline your approach in either verbal or mathematical form, showing calculations where necessary. Also, you must clearly specify any additional assumptions you have made to answer the question.

3. Do all problems until you reach the last page of the examination where "END OF EXAMINATION" is marked.

CONTINUE TO NEXT PAGE OF INSTRUCTIONS

4. Prior to the start of the exam, you will have a **fifteen-minute reading period** in which you can silently read the questions and check the exam booklet for missing or defective pages. A chart indicating the point value for each question is attached to the back of the examination. Writing will NOT be permitted during this time and you will not be permitted to hold pens or pencils. You will also not be allowed to use calculators. The supervisor has additional exams for those candidates who have defective exam booklets.

   - Verify that the table of the Normal Distribution is attached to the examination after the last question.

5. Your Examination Envelope is pre-labeled with your Candidate ID number, name, exam number and test center. Do not remove this label. Keep a record of your Candidate ID number for future inquiries regarding this exam.

6. Candidates must remain in the examination center until two hours after the start of the examination. The examination starts after the reading period is complete. You may leave the examination room to use the restroom with permission from the supervisor. To avoid excessive noise during the end of the examination, candidates may not leave the exam room during the last fifteen minutes of the examination.

7. At the end of the examination, place all answer sheets in the Examination Envelope. Please insert your answer sheets in your envelope in question number order. Insert a numbered page for each question, even if you have not attempted to answer that question. Nothing written in the examination booklet will be graded. Only the answer sheets will be graded. Also place any included reference materials in the Examination Envelope. BEFORE YOU TURN THE EXAMINATION ENVELOPE IN TO THE SUPERVISOR, BE SURE TO SIGN IT IN THE SPACE PROVIDED ABOVE THE CUT-OUT WINDOW.

8. If you have brought a self-addressed, stamped envelope, you may put the examination booklet and scrap paper inside and submit it separately to the supervisor. It will be mailed to you. Do not put the self-addressed stamped envelope inside the Examination Envelope. Interoffice mail is not acceptable.

   If you do not have a self-addressed, stamped envelope, please place the examination booklet in the Examination Envelope and seal the envelope. You may not take it with you. Do not put scrap paper in the Examination Envelope. The supervisor will collect your scrap paper.

   Candidates may obtain a copy of the examination from the CAS Web Site.

   All extra answer sheets, scrap paper, etc. must be returned to the supervisor for disposal.

9. Candidates must not give or receive assistance of any kind during the examination. Any cheating, any attempt to cheat, assisting others to cheat, or participating therein, or other improper conduct will result in the Casualty Actuarial Society and the Canadian Institute of Actuaries disqualifying the candidate's paper, and such other disciplinary action as may be deemed appropriate within the guidelines of the CAS Policy on Examination Discipline.

10. The exam survey is available on the CAS Web Site in the "Admissions/Exams" section. Please submit your survey by May 17, 2019.

END OF INSTRUCTIONS

THIS PAGE IS INTENTIONALLY BLANK

1. (6.5 points)

A startup is looking to enter the insurance business. Consider the following information about the company:

- The company has $10 million of capital
- The company is considering two lines of business, A and B
- Management would like to allocate capital using an approach that captures tail risk
- Underwriting results are uncorrelated with investment results
- There is no reinsurance
- There are no other expenses or taxes

The insurer ran 1,000 simulations of the returns on premium each line of business would generate, as well as the returns on investment a AAA Bond would generate. Below are selected results from this simulation, sorted from highest to lowest returns:

N	LOB_A	LOB_B	AAA Bond
991	0%	-50%	3%
992	0%	-50%	3%
993	0%	-50%	3%
994	0%	-50%	3%
995	0%	-50%	3%
996	0%	-50%	3%
997	-400%	-50%	3%
998	-450%	-50%	3%
999	-450%	-50%	3%
1000	-500%	-50%	3%

	LOB_A	LOB_B	AAA Bond
E(r)	10%	8%	3%
SD	33%	20%	0%

$Cov(R_A, R_B) = 5\%$

a. (2 points)

Justify a risk measure and determine which line of business is a more efficient use of capital from a risk-adjusted return on capital perspective.

b. (1 point)

Identify and briefly describe two arguments for why management should not invest solely in the more efficient line of business.

<QUESTION 1 CONTINUED ON NEXT PAGE>

1. (continued)

   c. (1.25 points)

   The company plans to write $10 million of gross written premium in its first year of operation. Determine the optimal amount of premium they should write in each of the above lines of business.

   d. (2.25 points)

   The board of directors has given the company the following investment constraint:

   The company may invest a portion of its capital in Stock C provided that it reduces the amount of insurance business across the combined lines of business A and B by the amount it chooses to invest in Stock C.

   Stock C produces an expected return of 8% with a standard deviation of 30%, and its expected returns are uncorrelated with the expected returns of the insurer's underwriting portfolio.

   Including underwriting and investments, determine the total return of the insurer's optimal risky portfolio as a percentage of its capital.

CONTINUED ON NEXT PAGE

2. (4.5 points)

An investor has constructed a portfolio according to the Markowitz Portfolio Optimization Model, from the set of fixed-income securities with the following features:

Bond	Coupon Frequency	Time to Maturity (years)	Par Value	Price	Current Yield	Yield to Maturity	Macaulay Duration	Portion of Portfolio
1	Annual	25	$1,000	$786.50	7.63%	8%	12.15	43.4%
2	N/A	2	$100	$ 92.46	0.00%			20.0%
3	Semi-annual	5	$1,000	$852.80	9.38%			36.6%

Covariance Matrix:

Bond	1	2	3
1	0.0144	0.0000	0.0072
2	0.0000	0.0000	0.0000
3	0.0072	0.0000	0.0400

a. (3.25 points)

Calculate the investor's risk aversion index, A.

b. (1.25 points)

Calculate the (Macaulay) duration of the investor's asset portfolio.

CONTINUED ON NEXT PAGE

3. (3.25 points)

Given the following information about an optimal risky portfolio constructed using a Single Index Model:

- There are 6 stocks in the active portfolio
- For the 6 stocks, $\sum_{i=1}^{6} \left(\frac{\alpha_i}{\sigma^2(e_i)}\right) = 0.5587$
- $\beta_{Active} = 1.0201$
- $\alpha_{Active} = 0.0202$
- $\sigma^2(e_{Active}) = 0.0362$
- Short positions are allowed
- The passive portfolio has an expected risk premium of 0.065 and a standard deviation of 0.1494

A 7th stock, Stock G, will be added to the active portfolio to create a new optimal risky portfolio.

A linear regression was performed on excess returns of the Market (independent variable) vs. the excess returns of Stock G (dependent variable). The regression produced the following results:

- Slope = 1.5948
- Standard Deviation of Residual (annualized) = 0.1931

For stock G, assume:

- Annual forecasted alpha = -0.008
- Annual standard deviation = 0.3067

a. (0.5 point)

Calculate the systematic and non-systematic components of Stock G's variance.

b. (1.75 points)

Calculate the weight of the active portfolio in the new optimal risky portfolio, including Stock G.

c. (1 point)

Identify and briefly describe one advantage and one disadvantage of the Single Index Model in comparison with the Markowitz Model.

CONTINUED ON NEXT PAGE

4. (4 points)

Given the following information:

- Covariance Matrix:

	Market	Stock A	Stock B	Stock C
Market	0.200			
Stock A	0.170	0.342		
Stock B	0.280	0.238	0.653	
Stock C	0.240	0.204	0.336	0.450

- Risk-Free Rate = 5.0%
- Market Price of Risk = 42.5%
- A portfolio manager uses a unique input list and calculates the following forecasted returns:

	Forecasted Return
Stock A	10.5%
Stock B	18.7%
Stock C	15.2%

a. (1.5 points)

Calculate the expected return of the market and each of the 3 stocks under CAPM.

b. (1.25 points)

Plot the Security Market Line. On the graph include:

i. The market portfolio
ii. The CAPM expected return for each stock
iii. The forecasted return for each stock

c. (1.25 points)

The portfolio manager recommends investing in the stock with the largest α. The portfolio manager's client has a utility function of U = Forecasted Return – $0.2\sigma^2$ and wants to invest in a single stock. Recommend and fully justify a stock for the client.

CONTINUED ON NEXT PAGE

5. (1.5 points)

Consider the following multifactor APT model for a particular firm:

Economic Factor	Factor Loadings	Risk Premium
Alternative Markets	0.4	8.0%
Job Growth	1.2	6.0%
Inflation	-0.3	1.5%

- A data breach at the firm results in a firm-specific component of -10%
- Factor loadings and risk premiums do not change after the data breach
- The risk-free rate is 3%

a. (1 point)

Calculate the expected rate of return for the firm before and after the data breach.

b. (0.5 point)

Briefly describe one advantage and one disadvantage of using a model based on APT instead of CAPM.

CONTINUED ON NEXT PAGE

6. (1.75 points)

Given the following $1,000 par value zero-coupon bonds with annual compounding:

Bond	Years to Maturity	Yield to Maturity	Price of Bond
A	1	5.00%	$952.38
B	2	6.50%	$881.66
C	3	y_C	$810.60
D	4	y_D	$735.03

a. (1 point)

Calculate the price of a $1,000 par value bond with 5% annual coupons maturing in four years.

b. (0.5 point)

Calculate the expected one-year short rate one year from now. Assume the expectations hypothesis is valid.

c. (0.25 point)

Calculate the expected one-year short rate one year from now. Assume the liquidity preference theory is valid with a constant liquidity premium of 2%.

CONTINUED ON NEXT PAGE

7. (3 points)

Given the following bonds with annual coupon payments:

Bond	Par Value	Time to Maturity (in years)	Annual Coupon Rate	Bond Price
1	$100	1	4%	$99.52
2	$100	2	2%	Not Given
3	$100	3	2%	Not Given
4	$100	4	0%	$81.03

The following forward rate agreements, valued as of today, are available for an investor to purchase:

Forward Rate Agreement	Lending Period Begins	Term	Principal	Annual Effective Interest Rate	Value (to Lender)
A	in 2 years	1 year	$700,000	6.6%	$6,000
B	in 3 years	1 year	$1,600,000	7.7%	$19,500

a. (2.25 points)

Calculate the price of Bond 3 assuming annually compounding interest.

b. (0.75 point)

An investor has developed the following probability distribution for future short rates in year 4:

Scenario	Year 4 Future Short Rate	Probability
1	6%	0.25
2	7%	0.50
3	10%	0.25

The investor is interested in purchasing Bond 4 but requires a liquidity premium of 1% in year 4 to engage in this long-term bond strategy. Based on the investor's expectation of future interest rates and liquidity premium criteria, recommend whether the investor should purchase Bond 4.

CONTINUED ON NEXT PAGE

8. (3.75 points)

Consider the following for a publicly-traded, monoline insurer:

- The insurer holds $50 million in surplus and writes $100 million in premium each year
- The expected loss and loss adjustment expense (LAE) ratio is 73%
- The underwriting expense ratio is 25%
- The insurer collects all premium and pays all underwriting expenses on January 1 of each year
- Losses and LAE are paid on December 31 of each year
- The insurer expects 92% of its business to retain each year
- The insurer's board of directors has decided to limit its investments to risk-free assets
- The company's target return on surplus is determined using the Capital Asset Pricing Model, and its CAPM beta is estimated at 1.25
- The expected return on the market portfolio is 12%
- The risk-free rate of return is 4%

a. (3.25 points)

Calculate the duration of the insurer's total economic value if the company assumes a pricing strategy of setting the target return as the risk-free rate of interest plus a risk premium, such that the initial target return is the CAPM estimate.

b. (0.5 point)

Briefly describe one advantage and one limitation of the insurer's pricing strategy.

CONTINUED ON NEXT PAGE

9. (2.75 points)

Two mortgages each with principal value of $50,000 are grouped into a $100,000 mortgage pool from which a collateralized mortgage obligation (CMO) is created with the following structure:

- Short-Pay Tranche A: $3,000 principal
- Intermediate-Pay Tranche B: $37,000 principal
- Long-Pay Tranche C: $60,000 principal

Assume:

- The annual mortgage rate is 5%
- Immediately after the first monthly payment, a prepayment of 25% occurs on each outstanding loan
- All proceeds from prepayment go to Tranche C
- The monthly payment on each mortgage loan is $943.56 and remains constant even after prepayment
- Payments are made at end of each month

a. (1.5 points)

Calculate the nominal value of the first principal payment to Tranche B.

b. (0.5 point)

Briefly explain how mortgage-backed securities are similar to callable bonds and identify the shape of the yield curve in a low interest rate environment.

c. (0.75 point)

Identify three reasons why Tranche C carries more risk than Tranche A.

CONTINUED ON NEXT PAGE

10. (2 points)

An asset manager wants to construct a Collateralized Debt Obligation Squared (CDO^2) composed of the junior tranches of two Collateralized Debt Obligations (CDOs).

Given the following:

- The CDOs are composed of two 2-year securities, which pay $500 at maturity and $0 at default
- One CDO is composed of securities with 10% default probability and the other CDO is composed of securities with 30% default probability
- All securities are uncorrelated
- Each CDO and CDO^2 has a junior tranche with attachment points 0% - 50% of the notional principal and a senior tranche with attachment points 50% - 100% of the notional principal
- The discount rate and risk-free rate are both 5%

a. (1 point)

Calculate the price of the senior tranche of the CDO^2.

b. (0.5 point)

Calculate the default premium of the senior tranche of the CDO^2.

c. (0.5 point)

Upon further review, the asset manager determines that the correct default probabilities should be 10 percentage points higher for each security. Discuss whether the CDO junior tranche or CDO^2 senior tranche is more sensitive to this change.

CONTINUED ON NEXT PAGE

11. (2.25 points)

Assume the following for a company that writes multiple lines of business:

- Beginning loss estimate is $20,000
- Loss estimates have equal probability of developing adversely by 15% or favorably by 10% each year
- Beginning Assets are $23,000
- Return on invested assets is 5% per year

a. (1.25 points)

Calculate the Expected Policyholder Deficit (EPD) Ratio at the end of year 2.

b. (0.5 point)

Calculate the asset value needed at the end of year 2 to ensure a 5% EPD ratio.

c. (0.5 point)

Explain why an EPD ratio capital requirement may exceed a rating agency capital requirement.

CONTINUED ON NEXT PAGE

12. (1.5 points)

A company is considering offering cyber risk insurance in addition to its single current line. The company will offer cyber risk insurance only if the return on the new line is greater than or equal to the target RAROC of the company.

Given the following table of 1,000 simulations of the aggregate loss distribution:

Sorted scenario	Current Line Loss ($million)	Cyber Risk Loss ($million)	Aggregate Loss ($million)
1	900	50	950
2	940	4	944
3	400	444	844
4	450	10	460
5	300	2	302
6	250	40	290
7	220	55	275
...	...	...	...

	Cyber Risk
Premium	$25 million
Expense	$1.25 million
Investment Return	4%
Discounted Losses at end of the year	$18 million
Undiscounted Losses	$22 million

- Target RAROC over one period is 8%
- Risk capital is calculated using 99.6% CTE and allocated using 99.6% Co-CTE
- Ignore other risks for the company
- Premium is received and expenses are paid at the beginning of the year

a. (1 point)

Calculate the cyber risk RAROC.

b. (0.5 point)

Calculate the additional risk margin required for the company to offer cyber risk insurance.

CONTINUED ON NEXT PAGE

13. (2 points)

An insurer has catastrophe exposure to three independent perils: water, wind, and earthquake.

		Loss Amount ($millions)			
Event	Probability	Water	Wind	Earthquake	Total
1	0.565	0	0	0	0
2	0.242	3	0	0	3
3	0.100	0	7	0	7
4	0.043	3	7	0	10
5	0.030	0	0	30	30
6	0.013	3	0	30	33
7	0.005	0	7	30	37
8	0.002	3	7	30	40
Total	1.000				

The assigned capital ($millions) by event for 3 layers is provided:

Event	$3 million excess $0 layer	$4 million excess $3 million layer	$3 million excess $7 million layer	Total
5	0.207	0.622	0.968	1.797
6	0.090	0.269	0.419	0.778
7	0.034	0.104	0.161	0.299
8	0.014	0.041	0.065	0.120

Using the Capital Allocation by Percentile Layer methodology with a 98.0% VaR capital requirement, determine how much capital should be allocated to the earthquake peril.

CONTINUED ON NEXT PAGE

14. (1.75 points)

An insurer has an opportunity to write a new program with the following characteristics:

- Premium of $1,000 collected and earned at time 0
- Expected loss of $650 paid at time 2
- Insurer cost of capital of 9%
- Expenses of $300, excluding commission, are incurred and paid at time 0
- The commission is incurred and paid at time 0
- Loss reserves are established at time 0 and there are no unearned premium reserves
- Surplus and reserves will be invested in a 2-year risk free zero coupon bond with a yield of 4%
- The required reserve to surplus ratio is 1.5
- There are no taxes

a. (1.25 points)

Determine the maximum commission as a percentage of premium so that the insurer's Internal Rate of Return (IRR) matches its cost of capital.

b. (0.5 point)

If the commission is fixed and expected losses are increased, describe the effects on projected investment income, and the IRR.

CONTINUED ON NEXT PAGE

15. (3.5 points)

Consider the following information for two insurance companies that write private passenger automobile business in the same state:

	Company A	Company B
Lines of business	Monoline auto	Multiline
Writes business in	Single state	Multistate
2017 written premium (millions)	$24	$825
2018 written premium (millions)	$45	$813
Premium-to-surplus ratio	3:1	1.5:1
Policy premium	$1,000	$1,000
Expected loss ratio	65%	70%
Expense ratio	30%	28%
Investment yield	5%	6%

For both companies:

- Premium is collected at policy inception
- Expenses are paid in the middle of the first year
- Losses will be paid at the end of each year according to the following pattern:

Year 1	Year 2	Year 3
50%	35%	15%

- The overall market return is 7%
- The risk-free rate is 4%
- Ignore taxes

a. (1 point)

For Company A, calculate the expected opportunity cost to an insured.

b. (0.5 point)

Identify and briefly describe whether Company A's expected operating profit from writing this policy should be more or less than the expected opportunity cost to the insured in part a. above.

c. (1.5 points)

The state's rate regulator is proposing to implement a benchmark return-on-equity that all companies must use in their ratemaking, where return is to be calculated by discounting all expected underwriting cash flows using each company's own investment return rate. Fully describe two reasons why this proposal does not constitute equitable rate regulation.

d. (0.5 point)

Identify an alternative basis for rate regulation and briefly explain why it is preferable to the proposal in part c. above.

CONTINUED ON NEXT PAGE

16. (3 points)

An insurance company is evaluating an opportunity to acquire a new line of business. Given the following information for the new line of business:

Loss (millions)	$55
Fixed Expense (millions)	$15
Variable Expense Ratio	20%
Investment Income on Surplus (millions), received at Time 1	$3
Risk-Free Rate	5%
Average Market Return	9%
Beta Coefficient for Losses	-0.25
Income Tax Rate, taxes are paid at Time 1	21%

Underwriting Cash Flow Patterns:

Time in Years	Premium Payment Pattern	Loss Payment Pattern	Expense Payment Pattern
0	0.60		0.30
1	0.40	0.40	0.70
2		0.60	

a. (2.5 points)

Calculate the profit provision using the Risk-Adjusted Discounted Cash Flow method, discounting all cash flows to Time 1.

b. (0.5 point)

The company will only move forward with the acquisition if the profit provision calculated in part a. above is positive. Identify and briefly describe whether this is appropriate.

CONTINUED ON NEXT PAGE

17. (2 points)

Given the following:

- Premium to Surplus Ratio: 2.0
- Pre-tax Investment Yield: 4%
- Invested Assets are equal to Surplus
- Effective Tax Rate: 20%
- All policies are cancelled at the end of the 2nd policy term
- PVI/ PVE Discount rate: 10%
- Premium is earned, and expenses are incurred at the beginning of a term
- Losses are incurred at the end of a term

Policy Term	Earned Premium	Incurred Loss	Incurred Expense
1	1,000	800	400
2	600	300	20

a. (1.5 points)

Calculate the return using the Present Value of Income Over Present Value of Equity (PVI / PVE) Method.

b. (0.5 point)

The company's goal is to achieve a steady state calendar year Return on Equity (ROE) of 10%. Identify two conditions for the Calendar Year ROE % and the PVI/PVE % to be equal to each other.

CONTINUED ON NEXT PAGE

18. (2.25 points)

Three standalone entities are considering forming a single company to reduce required funds.

Entity	Required Funds ($millions)
1	1.9
2	3.2
3	5.1

Company	Required Funds ($millions)
Entities 1&2	4.5
Entities 1&3	6.4
Entities 2&3	7.5
Entities 1&2&3	8.7

a. (1.25 points)

Based on the Shapley method, determine the amount each entity would contribute to the required funds to form a single company.

b. (0.5 point)

Briefly describe two conditions of rationality relating to game theory.

c. (0.5 point)

Determine the range of funds that could be contributed by Entity 2 and still satisfy the conditions of rationality.

CONTINUED ON NEXT PAGE

19. (1.25 points)

A company uses the following leverage ratio formula to determine a risk load based on events with loss, x, exceeding the 99.5th percentile:

$$L(x) = \frac{(1.25\ when\ x > x_{0.995}, else\ 0)}{1 - 0.995}$$

1,000 events are simulated with a mean loss of $50,000:

Simulated Event	Loss (in 000s)
1,000	100
999	93
998	88
997	81
996	77
995	76
994	74
993	73
992	71
991	58

Calculate the total required capital.

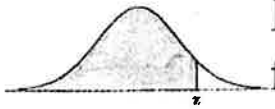
END OF EXAMINATION

Exam 9
Financial Risk and Rate of Return

POINT VALUE OF QUESTIONS

QUESTION	VALUE OF QUESTON	SUB-PART OF QUESTION (a)	(b)	(c)	(d)	(e)	(f)	(g)
1	6.50	2.00	1.00	1.25	2.25			
2	4.50	3.25	1.25					
3	3.25	0.50	1.75	1.00				
4	4.00	1.50	1.25	1.25				
5	1.50	1.00	0.50					
6	1.75	1.00	0.50	0.25				
7	3.00	2.25	0.75					
8	3.75	3.25	0.50					
9	2.75	1.50	0.50	0.75				
10	2.00	1.00	0.50	0.50				
11	2.25	1.25	0.50	0.50				
12	1.50	1.00	0.50					
13	2.00	2.00						
14	1.75	1.25	0.50					
15	3.50	1.00	0.50	1.50	0.50			
16	3.00	2.50	0.50					
17	2.00	1.50	0.50					
18	2.25	1.25	0.50	0.50				
19	1.25	1.25						
20	0.00							
21	0.00							
22	0.00							
23	0.00							
24	0.00							
25	0.00							
26	0.00							
27	0.00							
28	0.00							
29	0.00							
30	0.00							
31	0.00							
32	0.00							
33	0.00							
34	0.00							
35	0.00							
36	0.00							
37	0.00							
38	0.00							
39	0.00							
40	0.00							
41	0.00							
42	0.00							
43	0.00							
44	0.00							
45	0.00							
TOTAL	52.50							

Tables of the Normal Distribution



Probability Content from $-\infty$ to Z

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Values of z for selected values of Pr(Z<z)

z	0.842	1.036	1.282	1.645	1.960	2.326	2.576
Pr(Z<z)	0.800	0.850	0.900	0.950	0.975	0.990	0.995

EXAM 9 SPRING 2019 SAMPLE ANSWERS AND EXAMINER'S REPORT

SPRING 2019 EXAM 9 EXAMINER'S REPORT

The Syllabus and Examination Committee has prepared this Examiner's Report as a tool for candidates preparing to sit for a future offering of this exam. The Examiner's Report provides:

- A summary of exam statistics.
- General observations by the Syllabus and Examination Committee on candidate performance.
- A question-by-question narrative, describing where points were commonly achieved and missed by the candidates.

The report is intended to provide insight into what the graders for each question were looking for in responses that received full or nearly-full credit. This includes an explanation of common mistakes and oversights among candidates. We hope that the report aids candidates in mastering the material covered on the exam by providing valuable insights into the differences between responses that are comprehensive and those that are lacking in some way.

Candidates are encouraged to review the Future Fellows article from June 2013 entitled "Getting the Most out of the Examiner's Report" for additional insights.

EXAM STATISTICS:

- Number of Candidates: 601
- Available Points: 52.5
- Passing Score: 38.5
- Number of Passing Candidates: 338
- Raw Pass Ratio: 56.24%
- Effective Pass Ratio: 58.38%

GENERAL COMMENTS:

- Candidates should note that the instructions to the exam explicitly say to show all work; graders expect to see enough support on the candidate's answer sheet to follow the calculations performed. While the graders made every attempt to follow calculations that were not well-documented, lack of documentation may result in the deduction of points where the calculations cannot be followed or are not sufficiently supported.
- Candidates should justify all selections when prompted to do so. For example, if the candidate selects an all-year average and the question prompts a justification of all selections, a brief explanation should be provided for the reasoning behind this selection.
- Incorrect responses in one part of a question did not preclude candidates from receiving credit for correct work on subsequent parts of the question that depended upon that response.
- Candidates should try to be cognizant of the way an exam question is worded. They must look for key words such as "briefly" or "fully" within the problem. We refer candidates to the "Future Fellows" article from December 2009 entitled "The Importance of Adverbs" for additional information on this topic.

- Some candidates provided lengthy responses to a "briefly describe" question, which does not provide extra credit and only takes up additional time during the exam.
- Candidates should note that the sample answers provided in the examiner's report are not an exhaustive representation of all responses given credit during grading, but rather the most common correct responses.
- In cases where a given number of items were requested (e.g. "three reasons" or "two scenarios"), the examiner's report often provides more sample answers than the requested number. The additional responses are provided for educational value, and would not have resulted in any additional credit for candidates who provided more than the requested number of responses. Candidates are reminded that, per the instructions to the exam, when a specific number of items is requested, only the items adding up to that number will be graded (i.e., if two items are requested and three are provided, only the first two are graded).
- It should be noted that all exam questions have been written and graded based on information included in materials that have been directly referenced in the official syllabus, which is located on the CAS website. The CAS takes no responsibility for the content of supplementary study materials and/or manuals produced by outside corporations and/or individuals which are not directly referenced in the official syllabus.

QUESTION 1	
TOTAL POINT VALUE: 6.5	**LEARNING OBJECTIVES: A2, A4, A10, C8, D2**

SAMPLE ANSWERS

Part a: 2 points

Sample 1

Use TVaR 99% as a metric as it considers the tail risk associated with LOB A in the 4 worst observations.

$TVaR_{99\%}(A)=(0+0+0+0+0+0+[-400\%]+[-450\%]+[-450\%]+[-500\%])/10 = -180\%$
$TVaR_{99\%}(B)=([-50\%]+[-50\%]+[-50\%] +[-50\%] +[-50\%] +[-50\%] +[-50\%] +[-50\%] +[-50\%] +[-50\%]) /10 = -50\%$

Allocate -180% / (-180%-50%) = 78.3% of capital to LOB A, and 1 – 78.3% = 21.7% of capital to LOB B.

$RAROC_{LOB\ A}$ = 10% / 78.3% = 12.8%
$RAROC_{LOB\ B}$ = 8% / 21.7% = 36.9%

At a 99% TVaR, LOB A will achieve a slightly higher expected return but will require (180%/50%) or 3.6 times the capital of LOB B. Therefore, LOB B is a more efficient use of capital.

Sample 2

Allocate capital based on the co-CTE 99.5% as it considers the extent to which losses exceed the 99.5% VaR.

$CTE_{99.5\%}(A) = (0+[-400\%]+[-450\%]+[-450\%]+[-500\%])/5 = -360\%$
$CTE_{99.5\%}(B) = ([-50\%] +[-50\%] +[-50\%] +[-50\%] +[-50\%]) /5 = -50\%$
$CTE_{99.5\%}$(AAA Bond) = ([3%] +[3%] +[3%] +[3%] +[3%]) /5 = 3%

Allocate:
$10M * -360% / (-360% - 50% + 3%) = $8.85M of capital to LOB A
$10M * -50% / (-360% - 50% + 3%) = $1.23M of capital to LOB B
$10M * 1 - .885 - .123 = -$0.08M of capital to AAA Bond

$RAROC_{LOB\ A}$ = 10% / 8.85 = 1.13%
$RAROC_{LOB\ B}$ = 8% / 1.23 = 6.50%

Since LOB B has a RAROC that is 5.75 times higher than LOB A, management should invest in this line.

Part b: 1 point

Sample 1

- Diversification – LOB A and B are not perfectly correlated, so the insurer may achieve better expected returns on capital by writing LOBs A and B and diversifying its portfolio.
- Model Risk – It is possible that the simulation projections rely on an incorrect model, and LOB B does not always provide a significantly better risk-adjusted return on capital than LOB A.

Sample 2

- Volume Limitations – Since premium was not given for each line, it is possible that there are limits to the amount of growth that management can achieve in LOB B. Thus, as long as LOB A also satisfies management's cost of capital, it may make sense to also write LOB A.
- Bundling Products – It may be necessary to write LOB A to support LOB B to satisfy the customer's needs, such as pairing physical damage coverage with liability coverage.

Part c: 1.25 points

Treat the lines of business as two risky assets and use expected returns on premium and standard deviations –

$$W_A = \frac{E(R_A)\sigma^2{}_B - E(R_B)Cov(A,B)}{E(R_A)\sigma^2{}_B + E(R_B)\sigma^2{}_A - [E(R_A) + E(R_B)]Cov(A,B)}$$

=([10%-3%][.2]^2 - [8%-3%][.05])/([10%-3%][.2]^2 + [8%-3%][.33]^2 - [10%-3%+8%-3%][.05])

=13.4%

W_B=1 – 13.4% = 86.6%

Calculate optimal premium for each LOB

Prem(A) = \$10M x 13.4% = \$1.336M

Prem(B) = \$10M x 86.6% = \$8.664M

Part d: 2.25 points

Call the combo A and B D –

$E(r_D)$ = 13.36% x 10% + 86.64% x 8% =8.27%

Var(D)=([.1336 x .33]^2 + [.8664 x .2]^2 + 2[.134][.866][.05])^.5 = .0435

Combine C and D –

W_D = ([8.27%-3%][.3]^2 - [8%-3%][0])/([8.27%-3%][.3]^2 + [8%-3%].0435 - [8%-3%+8.27%-3%][0]) = 68.5%

Capital to D = \$6.85M

Investment Income = \$6.85M x 3.0% = \$205,500

Calculate the total return on capital –

Return on D = \$6.85M x (13.36% x 10% + 86.64% x 8%) = \$566,495

Return on Stock C = \$3.15M x 8.0% = \$252K

Total return = \$1,023,995

Return on capital = 1,023,995/10,000,000 = 10.2%

EXAMINER'S REPORT

Candidates were expected to recommend a line of business for management to write utilizing a risk-adjusted return on capital approach that satisfies management's preference for capital allocation. Then, candidates were expected to give two reasons why management may still want to write the other line of business despite this. Candidates were then expected to explore diversification opportunities by identifying the problem as a blending of risky assets and determining how to allocate resources between those assets to create an optimal risky portfolio.

Part a

Candidates were expected to select a tail risk measure to allocate capital to LOB A and B based on management's preferences. Then, they were expected to compare the return of each line to the allocated capital to form a recommendation on the most efficient use of capital.

Common mistakes included:

- Incorrect TVaR percentiles (i.e. TVaR at 96% rather than 99.6%)
- Lacking justification for the selection of the risk measure
- Selecting a risk measure that would not satisfy the preferences set by management in the question, such as VaR, EPD, or Variance
- Failing to compare the return of each line to its respective capital allocations, since the question specifically asked for support with risk-adjusted return on capital
- Using the Sharpe ratio to justify investment in a line, rather than comparing returns to capital
- Including a risk-free investment return on capital in the calculation of RAROC
- Calculating the return on capital in excess of the risk-free rate

Part b

Candidates were expected to identify and briefly describe two reasons why management might want to write the less efficient line of business in addition to the more efficient line justified in part a.

Examples of responses that did not receive credit included:

- Diversification between lines without also demonstrating that the two lines of business were not perfectly correlated, since diversification would not occur without this condition.
- Sensitivity to Risk Measure Selected – In the context of this question, even capital allocation based on a non-tail-based risk measure such as Variance (which was also provided) would not result in LOB A producing a higher RAROC.
- Economies of Scale reached by writing multiple LOBs – The question states that there are no expenses, so no expense savings could be obtained
- Purchasing reinsurance to mitigate tail risk – The question states that there is no reinsurance
- Stability – Investing in LOB A because it is profitable in more simulations than LOB B
- Cost of Capital – Stating that management should invest in LOB A because it also exceeds cost of capital. This does not explain why management should invest in this over the alternative.

Part c

Candidates were expected to recognize that the allocation of a fixed amount of premium was equivalent to creating an optimal risky portfolio.

Common mistakes included:

- Using the risk measure selected in part a to allocate the premium
- Calculation and formula errors within the weight formula
    - Using total return instead of excess return
    - Adding covariance terms instead of subtracting them
    - Calculator errors
    - Mismatching return and variance terms
    - Missing squared terms
    - Mistaking the given covariance for correlation

Part d

Candidates were expected to recognize that the tradeoff between insurance premium and capital invested in Stock C is equivalent to creating an optimal risky portfolio.

Common mistakes included:

- Failure to account for or incorrectly accounting for the risk-free investment of the capital supporting the insurance business
- Calculation errors within the weight formula
    - Using total return instead of excess return
    - Calculator errors
    - Mismatching return and variance terms
    - Missing squared terms
- Adjusting the given covariance using the standard deviations
- Treating the insurance business or individual LOBs as independent portfolios and then using Sharpe ratios or mean-variance criterion to exclude Stock C (essentially ignoring diversification benefits)
- Using the minimal variance shortcut to calculate asset weights

QUESTION 2

TOTAL POINT VALUE: 4.5 | **LEARNING OBJECTIVES: A1, A2, B2, B3**

SAMPLE ANSWERS

Part a: 3.25 points

Bond 2 is risk free since 0 variance

Set r = YTM

$r_1 = 8\%$

$r_2 = (100/92.46)^{1/2} = 4\%$

r_3: semi-annual coupon = (.0938/2) x 852.80 = 40

$852.00 = 40\,[1/(r_3/2)]\,[1 - 1/(1+(r_3/2))^{10}] + 1000/[1+(r_3/2)]^{10}$

by financial calculator: $r_3/2 = 6\%$

$r_3 = 12\%$

optimal risky portfolio -> compound of 1& 3

$w_1 = .434 / (.434+.366) = .5425 \quad w_3 = 1-.5425 = .4575$

$\sigma^2_{risky} = (.5425)^2\,(.0144) + (.4575)^2\,(.0400) + 2\,(.5425)\,(.4575)\,(.0072)$

$= .0162$

$E(r_{risky}) = .5425(8\%) + .4575(12\%) = 9.83\%$

$y^* = 1-.2 = .8 = [E(r_{risky}) - r_f] / A\,\sigma^2_{risky} = (.0983 - .04)/A\,(.0162)$

$A = 4.503$

Part b: 1.25 points

Sample 1

$D_1 = 12.15$ (given)

$D_2 = 2$ by definition, since zero coupon

$D_3 = [40(0.5)/1.12^{.5} + 40(1)/1.12^{1} + 40(1.5)/1.12^{1.5} + 40(2)/1.12^{2} + 40(2.5)/1.12^{2.5}$
$+ 40(3)/1.12^{3} + 40(3.5)/1.12^{3.5} + 40(4)/1.12^{4} + 40(4.5)/1.12^{4.5} + 40(5)/1.12^{5}]/852.8$

$= 3726.16/852.80 = 4.369$

$D_{portfolio} = .434\,(12.15) + .2(2) + .366(4.369) = 7.272$

Sample 2

Macaulay duration of #2 = 2

Bond #3 (discounted at 6% semi-annually)

Time	CF	PVCF	t PVCF
0.5	40	37.74	18.87
1.0	40	35.60	35.60
1.5	40	33.58	50.38
2.0	40	31.68	63.37
2.5	40	29.89	74.73
3.0	40	28.20	84.60
3.5	40	26.60	93.11
4.0	40	25.09	100.39
4.5	40	23.68	106.54
5.0	1040	582.73	2903.65
Total		852.80	3531.24

d_3 = 3531.24/852.80 = 4.14 years

Macaulay duration (asset) = 12.15x43.4% + 2x20% + 4.14x36.6%
= 7.19 years

EXAMINER'S REPORT

Candidates were expected to apply knowledge about the Markowitz Portfolio Optimization Model and work with bond concepts, including current yields, coupon rates, yield to maturities and Macaulay duration calculations. Candidates were expected to recognize when they were working with semi-annual numbers and when they were working with annual numbers and translate between these appropriately.

Part a

Candidates were expected to:

- Recognize from the given Covariance Matrix that bond 2 is a risk-free asset and to determine the annual yield-to-maturity (YTM) of this zero-coupon bond.
- Determine the annual YTM for bond 3, which has semi-annual payments.
- Understand that the Markowitz Portfolio Optimization Model optimizes the weights between the non-risk-free assets in the portfolio, and determine the weights implied by the problem for this optimization strategy.
- Use these weights to calculate the expected YTM for the risky portfolio and the variance of the risky portfolio.
- Use the values calculated above and the appropriate formula to calculate the investor's risk aversion index, A.

A handful of candidates attempted to calculate the YTM for bond 3 using the given information and the formula for the weights in the optimal risky portfolio. While this was a possible solution, it was a difficult approach that none were able to solve without error.

Common mistakes included:

- Using the bond 3 current yield to calculate the bond's annual coupon rate and then putting this into their YTM calculation as if it were a semi-annual cash flow.
- Calculating the bond 3 semi-annual YTM and then using this semi-annual YTM in the remainder of the problem (including Part b) as if it were an annual YTM.
- Not annualizing bond 3's semi-annual YTM correctly.
- Not rebalancing the weights given in the problem to reflect just the weights between the risky assets before beginning to calculate the expected rate and expected variance of the risky portfolio. (Note that this involved using weights that did not add up to unity.)
- Using current yields in the calculation of the expected rate of the risky portfolio, rather than yields to maturities.
- Not squaring the weights in the primary terms of the variance formula.
- Putting Covariance (1,3) into the Variance formula as if it were a coefficient of variation.
- Using the wrong variance formula.
- Setting y* equal to .2 (the risk-free portion) rather than to .8 (the risky portion.)
- Putting the standard deviation of the risky portfolio into the denominator of the risk aversion formula instead of the variance of the risky portfolio.

Part b

Candidates were expected to:

- Recognize that the duration of a zero-coupon bond is equal to the timing of that one payment.
- Calculate the Macaulay duration of a bond with regular semi-annual payments and a repayment of principal at the end of the bond's life.
- Weight the duration of assets together to calculate the Macaulay duration of the investor's asset portfolio.

Common mistakes included:

- Using incorrect coupons or incorrect discount rates in the duration calculation.
- Using incorrect weights to calculate the duration of the investor's asset portfolio

QUESTION 3

TOTAL POINT VALUE: 3.25 | **LEARNING OBJECTIVE: A5**

SAMPLE ANSWERS

Part a: 0.5 point

Sample 1

$0.3067^2 = 1.5948^2(0.1494)^2 + (0.1931)^2$

Systematic = 0.0568

Non-systematic = 0.0373

Sample 2

Systematic Risk = 1.5948^2 x 0.1494^2 = 0.05677

0.3067^2 = 0.094

Non-systematic = 0.094 – 0.05677 = 0.0373

Part b: 1.75 points

Sample 1

$$w_G^0 = \frac{\alpha_i}{\sigma^2(e_i)} = \frac{-.008}{.0373} = -.2145 = \text{initial wt, G}$$

$$\text{New } \sum w_i^0 = [.5587 + -.2145] = \underline{.3442} = \text{new denom}$$

$$w_i = \frac{w_i^0}{\sum w_i^0} = \text{wt of each stk in active portfolio (scaled wt)}$$

$$w_G = \frac{-.2145}{.3442} = -.623$$

$$w_{\text{all else}} = 1.623$$

New Active

$$\alpha_A = \sum w_i \alpha_i$$

$$\alpha_A = [-.008 * -.623 + 1.623 * .0202] = \underline{.0378}$$

$$\beta_A = \sum w_i \beta_i = [1.5948 * -.623 + 1.0201 * 1.623] = \underline{.6621}$$

$$\sigma^2(e_A) = \sum w_i^2 \sigma^2(e_i) = [-.623^2 * .0373 + 1.623^2 * .0362] = \underline{.1098}$$

$$w_A^0 = \frac{\alpha_A / \sigma^2(e_A)}{E(R_m) / \sigma_m^2} = \frac{.0378 / .1098}{.065 / .1494^2} = .1182$$

$$w_A^* = \frac{w_A^0}{1 + (1 - \beta_A) w_A^0} = \frac{.1182}{1 + (1 - .6621) * .1182} = \boxed{.11366}$$

Sample 2

Including Stock G:

Stock G $\frac{\alpha_G}{\sigma^2(e_i)} = \frac{-0.008}{0.0373} = -0.214$

New $\sum \frac{\alpha_i}{\sigma^2(e_i)}$ for 7 stocks $= 0.5587 - 0.214 = 0.344$

New active ptf weight $= w^0_{A(New)} = \frac{\left[\frac{\alpha_p^{New}}{\sigma^{2\,New}_{p(e_i)}}\right]}{\left[\frac{E(R_m)}{\sigma_m^2}\right]} = \frac{0.344}{\left(\frac{.065}{0.1494^2}\right)} = \frac{0.344}{2.91} = 0.1182$

$w_A^{New} = \frac{w_A^{o(N)}}{1 + (1 - \beta_{New})w_A^{0(N)}}$

$\beta_{New} = 1.0201\left(\frac{0.5587}{0.344}\right) + 1.5948\left(\frac{-0.214}{0.344}\right) = 0.6647$

$w_A^{New} = \frac{0.1182}{1 + (1 - 0.6647)(0.1182)} = \boxed{11.37\%}$

Part c: 1 point

Sample Responses for an advantage

- The Single Index Model allows for specialization in securities/sectors by offering a simple way to calculate covariance. If you had to estimate covariance between all securities like you do in Markowitz, then no one could become an expert in one sector.
- Less parameters to estimate which can also reduce the chance of miscalculating a parameter
- Pro of single index is there are much fewer parameters to estimate since it is based on correlation with the market. With the Markowitz model, you need to estimate correlations between all the pairs of stocks, which can be time-consuming

Sample Responses for a disadvantage

- Oversimplifies the calculations. The Markowitz model uses more information, including the full covariance matrix.
- Single index model ignores some important dependencies of stock return. It's inferior to Markowitz if stocks with correlated residuals take up a big portion of the portfolio
- Single index model can't handle sub-correlations like industry trends. Markowitz can because it would have correlations for all stocks and could model industry trends.
- SIM assumes the firm specific noise components are uncorrelated, if this is not the case, the Markowitz will take advantage of this resulting in a better risky portfolio….i.e. one with a higher Sharpe ratio

EXAMINER'S REPORT

Candidates were expected to demonstrate knowledge of the computations underlying the Single Index Model (SIM), understand the advantages and disadvantages of SIM relative to a full-covariance model (Markowitz), and formulate the appropriate active portfolio weight for a new optimal risky portfolio that incorporates an additional stock.

Part a

Candidates were expected to correctly identify and calculate the systematic and non-systematic components of risk for Stock G.

Common mistakes included:

- Calculating the non-systematic risk using the annual standard deviation instead of the standard deviation of the residuals
- Providing an incorrect formula for the systematic risk, most commonly failing to square beta

Part b

Candidates were expected to compute the active portfolio weight for a new optimal risky portfolio that is created by adding Stock G to the existing portfolio. To do so, candidates needed to compute restated weights for the initial stock portfolio and new Stock G, as well as adjusted risk parameters α, β, σ^2.

A common mistake was using the wrong σ^2 input for the ratio of alpha to residual variance for Stock G and/or the residual variance of the new Active portfolio ($\sigma^2(e_{Active})$), most commonly using the square of the annual standard deviation of Stock G (0.3067) instead of the square of the annualized standard deviation of the residual (0.1931). For example…

$$\alpha_G / \sigma^2(e_G) = \frac{-0.008}{0.3067^2} = -0.0850 \ll Incorrect$$

$$\alpha_G / \sigma^2(e_G) = \frac{-0.008}{0.1931^2} = -0.2145 \ll Correct$$

Part c

Candidates were expected to describe both and an advantage and a disadvantage of the Single Index Model relative to the Markowitz model.

Common mistakes included:

- Not stating why a particular fact provided an advantage or disadvantage. For instance, identifying that the Single Index Model has fewer parameters, without stating that this lowers parameter risk or would save time.
- Identifying an advantage or disadvantage without comparing it to Markowitz

QUESTION 4	
TOTAL POINT VALUE: 4	**LEARNING OBJECTIVE(S): A6**
SAMPLE ANSWERS	
Part a: 1.5 points	

Sample 1

$42.5\% = (E(r_M) - r_f) / \sigma_M^2 = (E(r_M) - .05) / 0.2$
$\Rightarrow E(r_M) = 13.5\%$

$\beta_A = cov(r_A , r_M) / \sigma_M^2 = 0.17/0.2 = 0.85$
$\Rightarrow E(r_A) = .05 + 0.85*(.135-.05) = 12.225\%$

$\beta_B = 0.28/0.2 = 1.4$
$\Rightarrow E(r_B) = .05 + 1.4*(.135-.05) = 16.9\%$

$\beta_C = 0.24/0.2 = 1.2$
$\Rightarrow E(r_C) = .05 + 1.2*(.135-.05) = 15.2\%$

Sample 2

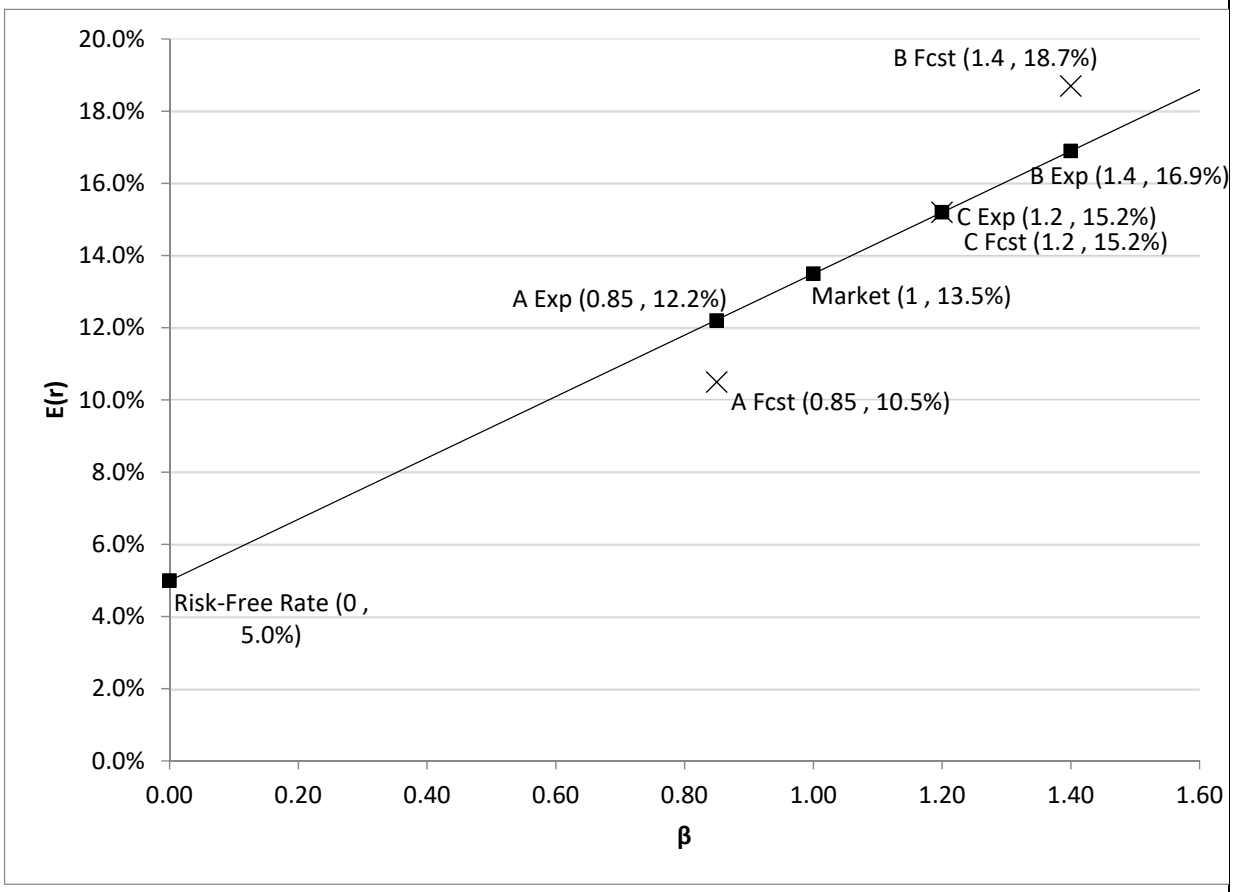
$E(r_i) = r_f + \beta_i*(E(r_M) - r_f) = r_f + (cov(r_i , r_M) / \sigma_M^2) * (E(r_M) - r_f)$

Market Price of Risk $= 0.425 = (E(r_M) - r_f) / \sigma_M^2 = (E(r_i) - r_f) / cov(r_i , r_M)$

$E(r_i) = 0.425*cov(r_i , r_M) + r_f$

$E(r_A) = 0.425*0.17 + 0.05 = 0.1223$
$E(r_B) = 0.425*0.28 + 0.05 = 0.169$
$E(r_C) = 0.425*0.24 + 0.05 = 0.152$
$E(r_M) = 0.425*0.20 + 0.05 = 0.135$

Part b: 1.25 points



Part c: 1.25 points

Sample 1

Stock B has the largest α (.187 - .169) = .018

U_A = .0366

U_B = .0564

U_C = .062

Stock C has highest utility

Invest in Stock C. It has the highest utility and there is no guarantee the alpha on B can be obtained due to fundamental risk, transaction costs, and model risk.

Sample 2

Since the client is only investing in a single stock, NOT a well-diversified portfolio, α is NOT important, since we still have firm-specific risk.

U_A = .105 - .20*(.342) = .0366

U_B = .187 - .20*(.653) = .0564

U_C = .152 - .20*(.45) = .062

=> Stock C maximizes the investor's utility and is greater than r_f. Choose C.

Sample 3

Portfolio manager (alpha)
A: 10.5% - 12.23% = -1.73%
B: 18.7% - 16.9% = 1.8% ✓
C: 0

Client (U)
A: 10.5% - 0.2*(0.342) = 0.0366
B: 18.7% - 0.2*(0.653) = 0.0564
C: 15.2% - 0.2*(0.45) = 0.062 ✓

Portfolio manager's strategy is to identify temporarily mispriced securities.
If all securities are at equilibrium price, then client's choice (Stock C) would be best, but this is not the case based on analysis.
Therefore, to exploit mispricing, one should invest in Stock B, which is underpriced now.

Sample 4

When investing in a single stock, appropriate volatility measure is standard deviation, and risk-return measure is sharpe ratio. α only applies when the investor is holding a well-diversified portfolio.

Sharpe Ratio$_i$ = E(R_i) / σ_i

	Sharpe Ratios	σ_i^2	Utility
A	.1235	.342	.0366
B	.1473	.653	.0564
C	.1521	.45	.062

Since Stock C has the highest sharpe ratio based on CAPM return and highest utility based on forecasted return, I recommend C.

Sample 5

U_A = 10.5% - 0.2*(.342) = 3.66%
U_B = 5.64%
U_C = 6.2%

α
A: -1.73%
B: 1.8%
C: 0%
Stock B has the highest α

y_B^* = (E(r_p) - r_f) / (0.4σ^2) = 0.525
E(r) = 0.525*0.187 + (1-0.525)*0.05 = 12.2%
σ^2 = (0.525^2) * 0.653 + $(1-0.525)^2$ * 0 = .18
U_B^* = 8.6%

y_C^* = 0.567

$E(r) = 10.8\%$
$\sigma^2 = .145$
$U_C^* = 7.9\%$

You can make them both happy if you buy a portfolio of 52.5% Stock B (w/ α= 1.8%) and 47.5% of risk-free assets. You get a utility of 8.6% which is higher than A, B, or C, or the optimal portfolio of C & risk-free.

EXAMINER'S REPORT

Candidates were expected to understand the fundamentals of the CAPM formula, how to express it in a graphical format with the Security Market Line, and synthesize a single-stock recommendation considering the portfolio manager's forecasts, CAPM expected return, client risk aversion, and single-stock risk.

Part a

Candidates were expected to apply the Market Price of Risk definition to obtain expected market return, use the covariance matrix to calculate stock betas, then use the CAPM formula to calculate expected returns for each stock.

Common mistakes included:

- Misinterpreting the market variance from the covariance matrix as market standard deviation
- Not using the definition of Market Price of Risk from the syllabus reading
- Not showing an answer for expected market return (only showing market risk premium)

Part b

Candidates were expected to express CAPM in a graphical format by drawing and labeling the following:

- Axes of Beta & Expected Return
- Security Market Line running through the risk-free rate (0, 0.05) and the Market Portfolio (1, 0.135)
- CAPM expected returns of Stocks A, B, and C
- Forecasted returns of Stocks A, B, and C

Common mistakes included:

- Mixing up the betas for Stocks B & C when plotting the points
- Not starting the SML at the risk-free rate (0, 0.05), or not labeling the SML intersection with the expected return axis
- Forgetting to label the expected return axis

Part c

Candidates were expected to provide the following in their response:

- Utility calculations for the single stocks
- Identify the stock with the highest utility
- Identify largest alpha stock OR give a valid argument against using alpha when selecting a single stock OR note the highest Sharpe ratio stock (and provide a valid argument for using Sharpe ratio over Portfolio Manager's alpha recommendation)
- Discuss the selections against one another OR note that they lead to the same stock
- Make a recommendation

Alternatively, candidates could address client risk aversion by constructing optimal complete portfolios where the risky portfolio is a single stock. When this was done, candidates were expected to provide the following in their response:

- Identify largest alpha stock OR give a valid argument against using alpha when selecting a single stock OR note the highest Sharpe ratio stock (and provide a valid argument for using Sharpe ratio over portfolio manager's alpha recommendation)
- Create optimal complete portfolio for stock with largest alpha OR create optimal complete portfolios for each of the three stocks OR (if argued for using Sharpe ratio over alpha) create optimal complete portfolio for stock with largest Sharpe ratio (using forecasted returns, to be consistent with utility formula)
- Utility calculations for the optimal complete portfolio(s). Show that utility for selected stock optimal complete improves over the single stock utilities and/or the other stocks' optimal complete portfolios (Note: if candidate selected stock for optimal complete based on forecasted return Sharpe ratio, could simply state that the stock with the largest Sharpe ratio will have the highest optimal complete utility for a risk-averse client, because this can be shown theoretically to be true.)
- Discuss selection and clearly state the recommended strategy

Common mistakes included:

- Not discussing the Portfolio Manager's selection of largest alpha
- Not considering the client's utility in the response
- Misinterpreting the stock variances from the covariance matrix as standard deviations
- Calculating utilities with CAPM expected return instead of using the given formula
- Recommending using the stock with the highest Sharpe ratio without discussing *why* it's superior to Portfolio Manager's alpha for a single stock

QUESTION 5

TOTAL POINT VALUE: 1.5 | **LEARNING OBJECTIVE: A8**

SAMPLE ANSWERS

Part a: 1 point

Sample 1

Before: E(r) = 0.03 + 0.4(0.08) + 1.2(0.06) – 0.3(0.015) = 0.1295
After: E(r) = .1295 – 0.10 = 0.0295

Sample 2

Expected return before breach:
$E(r) = r_f + B_1*RP_1 + B_2*RP_2 + B_3*RP_3 = 0.03 + 0.4(0.08) + 1.2(0.06) + (-0.3)(0.015) = 0.1295$

According to APT the expected return of the firm-specific component is 0.

Expected return after breach:
0.1295

Part b: 0.5 point

Advantages:

- Does not require the all-inclusive portfolio that CAPM requires
- APT requires fewer investors in the market to achieve equilibrium pricing
- APT doesn't require all investors to be rational mean-variance optimizers
- APT allows for correlations within specific industries and other factors that behave different to market risks where CAPM focuses on market systematic risks

Disadvantages:

- The portfolio under APT may not be sufficiently diversified
- APT assumes people would take unlimited positions which is not realistic. CAPM assumes investors take small positions

EXAMINER'S REPORT

Candidates were expected to know how to use APT to determine the expected return for a security and compare/contrast with CAPM and factor models.

Part a

Candidates were expected to use APT to determine the expected return for a security.

Common mistakes included:

- Not adding the risk-free rate when calculating the expected return.
- Subtracting the risk-free rate from each individual economic risk premium factor.

Part b

Candidates were expected to be able to point out the difference between APT and CAPM and be able to list out advantages and disadvantages of APT compared to CAPM.

Common mistakes included:

- APT have multiple factors while CAPM only has one factor.
- APT has short sale limitations while CAPM does not.

QUESTION 6

TOTAL POINT VALUE: 1.75	**LEARNING OBJECTIVES: B1, B2**

SAMPLE ANSWERS

Part a: 1 point

Sample 1

$810.60 = 1000 / (1 + y_c)^3$, $y_c = 7.25\%$

$735.03 = 1000 / (1 + y_d)^4$, $y_d = 8\%$

$Price = 50 / 1.05 + 50 / 1.065^2 + 50 / 1.0725^3 + 1050 / 1.08^4 = 904.01$

Sample 2

$Price = 952.38 * 50 / 1000 + 881.66 * 50 / 1000 + 810.60 * 50 / 1000 + 735.03 * 1050 / 1000 = 904.01$

Sample 3

$810.60 = 1000 / (1.065^2 * (1 + r_3))$, $r_3 = 8.77\%$

$735.03 = 1000 / (1.065^2 * 1.0877 * (1 + r_4))$, $r_4 = 10.28\%$

$Price = 50 / 1.05 + 50 / 1.065^2 + 50 / (1.065^2 * 1.0877) + 1050 / (1.065^2 * 1.0877 * 1.1028) = 904.01$

Part b: 0.5 point

Sample 1

Under expectations hypothesis, expected short rate = forward rate

$1 + f_2 = (1 + s_2)^2 / (1 + s_1) = 1.065^2 / 1.05$, $f_2 = 8.02\%$

Sample 2

$Expected_{1,2} = 952.38 / 881.66 - 1 = 8\%$

Part c: 0.25 point

Sample 1

Under liquidity preference theory, expected short rate = forward rate - liquidity premium

8.02% - 2% = 6.02%

EXAMINER'S REPORT

Candidates were expected to use bond prices to calculate yields to maturity, use those yields in calculating the price of another bond, calculate forward rates, and understand the expectations hypothesis and the liquidity preference theory.

Part a

Candidates were expected to calculate the price of the bond, which included the amount and timing of payments, and calculating the discount factor for each time-period (which could be accomplished by using yield to maturities, ratios of the zero-coupon bond prices, or forward rates).

Common mistakes included:

- Calculating the price of the bond using a fixed 8% yield for each of the payments, rather than the corresponding yield for that year's zero-coupon bond.
- Calculation errors in interim steps.

Part b

Candidates were expected to calculate the forward rate for the second year and apply the expectations hypothesis to arrive at the expected short rate.

A common mistake was calculating the expected one-year short rate two years from now, rather than one year from now, i.e. $1.0725^3 / 1.065^2 - 1 = 8.77\%$

Part c

Candidates were expected to apply liquidity preference theory by adjusting the forward rate calculated in part b by the liquidity premium to arrive at the expected short rate.

A common mistake was adding the liquidity premium to the forward rate rather than subtracting it, i.e. 8% + 2% = 10%

QUESTION 7	
TOTAL POINT VALUE: 3	**LEARNING OBJECTIVES: B1, B2**
SAMPLE ANSWERS	
Part a: 2.25 points	

Sample 1 – Buyer Value

y1 = [104 / 99.52] - 1 = 4.5%
y4 = [100 / 81.03]^(0.25) - 1 = 5.4%
19,500 = [1,600,000 (0.077 – f3)] / [(1+y4)^4]
f3 = 6.20%
(1+y3)^3 = [(1+y4)^4] / (1+ f3)
y3 = 5.14%
6,000 = [700,000 (0.066 – f2)] / [(1+y3)^3]
f2 = 5.60%
(1+y2)^2 = [(1+y3)^3] / (1+ f2)
y2 = 4.90%
Price of Bond 3 = (2/(1.045)) + (2/(1.049)^2) + (102/(1.0514)^3) = 91.50

Sample 2 – Lender Value

y1 = [104 / 99.52] - 1 = 4.5%
y4 = [100 / 81.03]^(0.25) - 1 = 5.4%
19,500 = [1,600,000 (f3 - 0.077)] / [(1+y4)^4]
f3 = 9.20%
(1+y3)^3 = [(1+y4)^4] / (1+ f3)
y3 = 4.16%
6,000 = [700,000 (0.066 – f2)] / [(1+y3)^3]
f2 = 7.60%
(1+y2)^2 = [(1+y3)^3] / (1+ f2)
y2 = 2.48%
Price of Bond 3 = (2/(1.045)) + (2/(1.0248)^2) + (102/(1.0416)^3) = 94.08

Sample 3 – Buyer Value (FRA is discounted by forward rate to beginning of FRA period)

y1 = [104 / 99.52] - 1 = 4.5%
(1 + y4)^4 = [100 / 81.03] = 1.234
19,500 = [1,600,000 (0.077 – f3)] / [(1 + f3)]
f3 = 6.40%
6,000 = [700,000 (0.066 – f2)] / [(1+ f2)]
f2 = 5.69%
f1 = [(1 + y4)^4] / [(1+y1) * (1+f3) * (1+ f2)] – 1 = 5.01%
Price of Bond 3 = (2/(1.045)) + (2/[(1.045)*(1.0501)]) + (102/[(1.045)*(1.0501)*(1.0569]) = 91.68

Sample 4 – Buyer Value (No discounting)

y1 = [104 / 99.52] - 1 = 4.5%
(1 + y4)^4 = [100 / 81.03] = 1.234
19,500 = [1,600,000 (0.077 – f3)]
f3 = 6.48%
6,000 = [700,000 (0.066 – f2)]
f2 = 5.74%
f1 = [(1 + y4)^4] / [(1+y1) * (1+f3) * (1+ f2)] – 1 = 4.88%

Price of Bond 3 = (2/(1.045)) + (2/[(1.045)*(1.0488)]) + (102/[(1.045)*(1.0488)*(1.0574)]) = 91.75

Sample 5 – Forward Rate = given yield rate
y1 = [104 / 99.52] - 1 = 4.5%
(1 + y4)^4 = [100 / 81.03] = 1.234
Assume f3 = 7.70% and f2 = 6.60%
(1 + y3)^3 = [(1 + y4)^4 / (1+f3)] = 1.146
(1 + y2)^2 = [(1 + y3)^3 / (1+f2)] = 1.075
Price of Bond 3 = (2/1.045) + (2/1.075) + (102/1.146) = 92.79

Sample 6 – Forward Rate = given yield rate
y1 = [104 / 99.52] - 1 = 4.5%
(1 + y4)^4 = [100 / 81.03] = 1.234
Assume f3 = 7.70% and f2 = 6.60%
f1 = [(1 + y4)^4] / [(1+y1) * (1+f3) * (1+ f2)] – 1 = 2.9%
Price of Bond 3 = (2/(1.045)) + (2/[(1.045)*(1.029)]) + (102/[(1.045)*(1.029)*(1.066]) = 92.79

Part b: 0.75 point

Sample 1
rt is the future short rate from t to t+1.
Liquidity Premium = f3 – E(r4) which must be > 1% for the investor to engage in a long-term bond.
E(r4) = (.25)(.06) + (.50)(.07) + (.25)(.10) = 7.5%
Liquidity Premium = 6.2% - 7.5% = -1.3% < 1%
The investor should not purchase Bond 4 because it doesn't offer the required liquidity premium.

Sample 2
rt is the future short rate from t to t+1.
E(r4) = (.25)(.06) + (.50)(.07) + (.25)(.10) = 7.5%
f3 – Liquidity Premium must be greater than 7.5% for the investor to engage in a long-term bond
6.2% - 1% = 5.2%
The expected year 4 short rate is less than the desired 7.5% rate so do not purchase bond 4

Sample 3
E(r4) + Liquidity Premium = f3
E(r4) + 1% = (.25)(.06) + (.50)(.07) + (.25)(.10) + 1% = 8.5%
8.5% > 6.2%
The year 4 forward rate is less than the desired 8.5% rate so do not purchase bond 4

Sample 4
f3 = E(r4) + Liquidity Premium
f3 = E(r4) + 1% = (.25)(.06) + (.50)(.07) + (.25)(.10) + 1% = 8.5%
Bond Price 4 with forward rate expectation
= 100 / [(1.045)*(1.029)*(1.066)*(1.085)] = 80.40
80.40 < 81.03 (given)
The bond is overpriced based on the investors liquidity premium expectations so do not purchase bond 4.

Sample 5
f3 = E(r4) + Liquidity Premium
Calculated f3 = 6.2% (from part (a))
The desired yields with liquidity premium are equal to 7%, 8%, and 11% (given short rates + 1% liquidity). The future short rate is less than the lowest desired yield according to the probability distribution so I do not recommend purchasing bond 4.

Sample 6
y4 = (81.03/100)^0.25 = 5.4%
f3 = E(r4) + 1% = (.25)(.06) + (.50)(.07) + (.25)(.10) + 1% = 8.5%
Investor's expectations = ((1 + y1) * (1 + f1) * (1 + f2) * (1 + f3))^0.25 - 1
= (1.045 * 1.029 * 1.066 * 1.085)^0.25 – 1 = 5.6%
5.4% < 5.6%
The current bond 4-year annual yield does not meet the investor's expectations so I do not recommend purchasing bond 4.

EXAMINER'S REPORT

Candidates were expected to understand the relationship between spot rates, short rates, forward rates, and bond prices. Candidates were expected to be familiar with the liquidity preference theory.

Part a

Candidates were expected to use the given bond and forward rate agreement (FRA) assumptions to calculate the appropriate spot rates and/or forward rates to price bond 3 appropriately. Candidates were expected to demonstrate how to calculate spot rates from annual coupon bonds, how to calculate spot rates from forward rates, and how to calculate the price of a bond.

Understanding how to price an FRA was not a requirement; therefore, many interpretations of the FRA were accepted, including:

- Evaluating the FRA from the perspective of both the buyer and lender
- Evaluating the price of the FRA at the beginning of the FRA period
- Evaluating the price of the FRA at the end of the FRA period
- Evaluating the price of the FRA at time 0
- Candidates treating the given effective interest rates as forward rates

Common mistakes included:

- Using forward rates (or spot rates) as spot rates (or forward rates)
- Applying the derived forward rates from the FRA for years 1-2 and 2-3 rather than 2-3 and 3-4
- Discounting the forward rate agreement equation setup to time 1 rather than time 0
- Using the wrong coupon payments when calculating the price of Bond 3
- Using the wrong spot rate when discounting the coupon payments
- Using continuous compounding
- Calculation errors in getting from the correct formulas to the final answer

Part b

Candidates were expected to calculate an expected return given the future short rate distribution and apply the liquidity premium requirement. This expected return should have been directly compared to a calculated forward rate from part a. Based on that comparison, candidates were expected to provide a recommendation on whether to invest in bond 4.

Common mistakes included:

- Not addressing the liquidity premium requirement at all
- Subtracting the liquidity premium requirement from the expected short rate
- Not carrying over forward rate assumptions from part a.
- Providing an incorrect comparison (such as the expected short rate compared to the spot rate)
- Providing an incorrect recommendation based on the comparison of forward rate and expected short rate
- Incorrectly calculating the present value of the bond prices

QUESTION 8	
TOTAL POINT VALUE: 3.75	**LEARNING OBJECTIVES: A6, B4**
SAMPLE ANSWERS	
Part a: 3.25 points	

Sample 1

$k = r_f + \beta * (E(r_m) - y)$
$= 0.04 + 1.25 * [0.12 - 0.04]$
$= 0.14$

$k = a + b * y$
$= 0.10 + (1)(0.04)$

$a = 0.10$
$b = 1.00$
$y = 0.04$

$$Current\ Economic\ Value = S + P - E - \frac{L}{1+y}$$
$$= 50 + 100 - 100(0.25) - \frac{100(0.73)}{1.04}$$
$$= 54.808M$$

$$Franchise\ Value = \frac{(cr)(S)(a+by-y)}{(1+y)(1+y-cr)} = \frac{(0.92)(50)[(0.14)-0.04]}{(1.04)(1.04-0.92)} = 36.859M$$

$$Duration\ of\ Current\ Value = 1.00$$

$$Duration\ of\ Franchise\ Value = \frac{a-b+1}{(1+y)(a+by-y)} + \frac{1}{1+y-cr}$$

$$= \frac{0.10-1+1}{(1.04)(0.14-0.04)} + \frac{1}{1.04-0.92} = 9.295$$

$$Duration\ of\ Total\ Economic\ Value = \frac{54.808(1.00) + 36.859(9.295)}{54.808 + 36.859} = 4.335$$

Sample 2

$CAPM\ \ E(r) = .04 + 1.25(.12 - .04) = 14\%$
$S = 50M\ \ P = 100M\ \ E(L) = .73 * 100M = 73M$
$E = .25 * 100M = 25M\ \ cr = .92$

$Pricing\ Strategy$

$$\begin{array}{rcl} & a & + \quad by \\ k = risk\ premium & + & r_f \\ .14 = & a & + .04 \end{array}$$

$a = .10 \quad b = 1$

$$C = S + P - E - \frac{L}{1+y}$$

$$50M + 100M - 25M - \frac{73M}{1.04} = 54.81M$$

$$F = \left(P - E - \frac{L}{1+y}\right) * \frac{d}{1-d} \qquad d = \frac{cr}{1+y} = \frac{.92}{1.04} = .885$$

$$\left(100M - 25M - \frac{73M}{1.04}\right) * \frac{.885}{1-.885} = 36.998M$$

$$D_C = 1$$

$$D_F = \frac{a - b + 1}{(1+y)(a+by-y)} + \frac{1}{1+y-cr}$$

$$\frac{.10 - 1 + 1}{(1.04).10 + 1 * .04 - .04)} + \frac{1}{1.04 - .92} = 9.295$$

$$D_{TEV} = \frac{1 * 54.81M + 9.295 * 36.998M}{54.81M + 36.998M} = 4.343\ years$$

Part b: 0.5 point

Sample answers for advantages:

- Greatly reduces duration, which reduces interest rate risk.
- Protects/saves the insurer from rating agency or regulatory scrutiny, which would occur if the insurer tried to reduce total duration by reducing the duration of its assets.
- Pricing strategy is invisible to regulators, so they won't have concerns that our strategy puts solvency in jeopardy.
- Flexible to achieve both target D and return on surplus to react to interest rate change.
- This method is invisible to regulators, which may be concerned if company shifts investment strategy to hedge a risk invisible to regulator.

Sample answers for disadvantages:

- Only works for a narrow range of interest rates.
- Duration changes as interest rates change and needs to be recalculated with liabilities rebalanced.
- The portfolio needs to be rebalanced with the change in interest rate.

EXAMINER'S REPORT

Candidates were expected to understand how the given pricing strategy would be evaluated through Panning's framework, in terms of the company's duration of total economic value and the implications on its exposure to interest rate risk or to regulatory/rating agency concerns.

Part a

Candidates were expected to interpret the given pricing strategy and select proper parameters to calculate the duration of total economic value.

Common mistakes included:

- Selecting the parameter b in the k = a + b * y formula to be any number other than 1 without proper justification, since the prompt indicates that the target return is set as the risk-free rate plus a risk premium.
- Not recognizing that y in the k = a + b * y formula is the risk-free interest rate, and then applying a different selection for that variable.
- Applying incorrect formulas for the duration of franchise value, by using incorrect signs or operations between parameters.
- Assuming a value other than 1 for the duration of current economic value without proper justification, or with incorrect calculations.
- Calculating Current Economic Value by including investment income.

Part b

Candidates were expected to evaluate the given strategy versus not setting the target return as the risk-free rate of interest plus a risk premium.

Common mistakes for advantages included:

- Stating that the method or its inputs are well-established or easy to calculate, without proper explanation on why an alternate method would be harder to calculate.
- Simply stating that the strategy reduces duration, without explaining why that is an advantage or comparing it to an alternate strategy.

Common mistakes for disadvantages included:

- Stating that the method or its inputs are complex or difficult to calculate, without proper explanation on why an alternate method would be easier to calculate.
- Stating that the company's insurance rates would need to change over time, without explaining what would cause the given strategy to trigger that need.
- Addressing disadvantages of the CAPM model.
- Stating that the target return changes over time.
- Addressing disadvantages of the board of directors' investment strategy.

QUESTION 9	
TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE: C4**

SAMPLE ANSWERS

Part a: 1.5 points

Sample 1

[*Simple interest solution*]
Interest @ time 1 : (0.05 / 12) * 50,000 = 208.33
Principal @ time 1 : 943.56 – 208.33 = 735.23
Principal after : 50,000 – 735.23 = 49,264.77
Remove pre-payment : .75 * (49,264.77) = 36,948.58
Remaining to A : 3,000 – 2 * 735.23 = 1,529.54

Interest @ time 2 : (0.05 / 12) * 36,948.58 = 153.95
Remaining to A : 1,529.54 – 2 * (943.56 – 153.95) = -49.68
49.68 owed to B

Sample 2

[*Compound interest solution*]
Interest @ time 1 : (1 + 0.5)^(1/12) * 50,000 – 50,000 = 203.71
Principal @ time 1 : 943.56 – 203.71 = 739.85
Principal after : 50,000 – 739.85 = 49,260.15
Remove pre-payment : .75 * (49,260.15) = 36,945.11
Remaining to A : 3,000 – 2 * 739.85 = 1,520.29

Interest @ time 2 : (1 + 0.5)^(1/12) * 36,945.11 – 36,945.11 = 150.52
Remaining to A : 1,520.29 – 2 * (943.56 – 150.52) = -65.79
65.79 owed to B

Sample 3

Interest @ time 1 : (0.05 / 12) * 50,000 = 208.33
Principal @ time 1 : 943.56 – 208.33 = 735.23
Principal after : 50,000 – 735.23 = 49,264.77
Remove pre-payment : .75 * (49,264.77) = 36,948.58
Remaining to A : 3,000 – 2 * 735.23 = 1,529.54
0 paid to B with first principal payment

Part b: 0.5 point

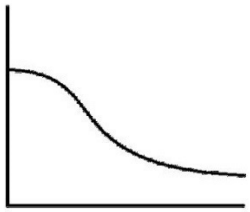
Sample 1

When interest rates fall, mortgagees may repay the principal balance and borrow at a lower rate. This is similar to a callable bond. The yield curve has negative convexity when interest rates are low for both. But the price for a callable bond is capped at the call price. For MBS, the price is capped slightly higher than the principal balance as not all people will refinance.

Sample 2

Similar to a callable bond in that the borrower will "call" or prepay the loan if the value of the loan is larger than the principal balance.

Price



Yield

Part c: 0.75 point

Any three of the following:

- Tranche C experiences defaults first
- Higher interest rate risk
- Longer term, subject to liquidity risk
- Tranche C is exposed to pre-payment risk
- Tranche C has a larger principal balance than Tranche A
- Tranche C is more sensitive to errors in correlation assumption
- Due to longer payment time horizon, more susceptible to inflation risk

EXAMINER'S REPORT

Candidates were expected to understand the structure, hierarchy, and operation of a mortgage backed security.

The question included a unique feature where the pre-payment proceeds benefited tranche C. Candidates were expected to demonstrate how this payment affected the total balance of the mortgage backed security, and subsequent principal and interest payments to the different tranches. Solutions that assumed the pre-payment to C altered the seniority of the tranches as it related to future principal payments were not awarded full credit.

Part a

Candidates were expected to demonstrate an understanding of the payment mechanics around a multi-tranche mortgage backed security. They were expected to take the mortgage payments and pre-payments from the underlying pool and show how these cashflows impacted each tranche.

Common mistakes included:

- Allocating the mortgage principal payments to each tranche proportionally
- Forgetting that there are two mortgages (and therefore two payments) making up the pool
- Calculating the 25% pre-payment based off the original notional balance of 50,000 per mortgage
- Assuming the pre-payment to tranche C made it senior to tranches A and B

Part b

Candidates were expected to understand the unique prepayment/call features of both mortgage backed securities and callable bonds, and how these features affect the corresponding yield curve.

Answers that only stated the shape of the yield curve was a similarity between MBS and callable bonds were not given full credit.

A common mistake was stating the MBS yield curve is flat in a low interest rate environment

Part c

Candidates were expected to understand the risks affecting mortgage backed securities, and which risks disproportionally impact the long-pay, junior, tranche.

A common mistake was identifying risks not attributable to the stated situation.

QUESTION 10

TOTAL POINT VALUE: 2 | **LEARNING OBJECTIVES: C1, C3**

SAMPLE ANSWERS

Part a: 1 point

Sample 1

$\Pr(Default\ CDO_{Junior1}) = 1 - 0.9^2 = 0.19$

$\Pr(Default\ CDO_{Junior2}) = 1 - 0.7^2 = 0.51$

$\Pr(Default\ CDO^2_{Senior}) = 0.19 \times 0.51 = 0.0969$

$$Price\ CDO^2_{Senior} = \frac{500 \times (1 - 0.0969)}{1.05^2} = \$409.57$$

Sample 2

$\Pr(Default\ CDO_{Junior1}) = 2 \times 0.1 \times 0.9 + 0.1^2 = 0.19$

$\Pr(Default\ CDO_{Junior2}) = 2 \times 0.3 \times 0.7 + 0.3^2 = 0.51$

$\Pr(Default\ CDO^2_{Senior}) = 0.19 \times 0.51 = 0.0969$

$$Price\ CDO^2_{Senior} = \frac{500 \times (1 - 0.0969)}{1.05^2} = \$409.57$$

Sample 3

$\Pr(Default\ CDO_{Junior1}) = 1 - 0{,}9^2 = 0.19$

$\Pr(Default\ CDO_{Junior2}) = 1 - 0{,}7^2 = 0.51$

$\Pr(Default\ CDO^2_{Senior}) = 0.19 \times 0.51 = 0.0969$

$$Price\ CDO^2_{Senior} = \frac{1000 \times (1 - 0.0969)}{1.05^2} = \$819.14$$

Part b: 0.5 point

$$CDO^2\ yield = \sqrt{\frac{500}{409.57}} - 1 = 10.49\%$$

$Risk\ Free = 5\%$

$Default\ Premium = 10.49\% - 5\% = 5.49\%$

Part c: 0.5 point

Sample 1

Compute new CDO probabilities of default with updated probabilities

$\Pr(Default\ CDO_{Junior1}) = 1 - 0.8^2 = 0.36$

$\Pr(Default\ CDO_{Junior2}) = 1 - 0.6^2 = 0.64$

$\Pr(Default\ CDO^2_{Senior}) = 0.36 \times 0.64 = 0.2304$

Compute variation from part a

$\Delta(Default\ CDO_{Junior1}) = {}^{0.36}/_{0.19} - 1 = 89\%$

$\Delta(Default\ CDO_{Junior2}) = {}^{0.64}/_{0.51} - 1 = 25\%$

$\Delta(Default\ CDO^2_{Senior}) = {}^{0.2304}/_{0.0969} - 1 = 138\%$

We see that CDO^2_{Senior} probability of default has increased the most, therefore it is more sensitive to a change in default probabilities of the underlying securities.

Sample 2

The CDO^2 senior tranche is more sensitive to variation in default probabilities of the underlying securities since it compounds the effect from the junior tranches of the CDOs from which it is built.

Sample 3

CDO^2 are leveraged and thus, the impacts of increasing the default probabilities of the securities are magnified. Hence, the CDO^2 senior tranche will be more sensitive.

EXAMINER'S REPORT

Candidates were expected to understand how CDO and CDO^2 are built and priced, to perform various calculation around the CDO concept and to understand the responsiveness to underlying parameters.

Part a

Candidates were expected to know how to compute the probability of default for various tranches of CDO and CDO^2, and to price the CDO^2.

Common mistakes included:

- Not understanding that each CDO is composed of the same 2 underlying securities (CDO_1 is composed of two 10% default securities and CDO_2 is composed of two 30% default securities)
- Failure to discount the price of the senior tranche of the CDO^2 to t = 0
- Discounting only one year instead of two as stated in question
- Calculating incorrect probabilities for the underlying CDOs

Part b

Candidates were expected to know that default premium is the difference between the CDO^2 return and the risk-free rate.

Partial credit was awarded if the default premium was computed as the difference between $500 at time 0 (using risk-free rate) and the price of the CDO^2

Common mistakes included:

- Not considering the risk-free rate
- Errors in computing the CDO^2 yield to maturity
- Not discounting to t=0 (2 years)
- Assuming the price computed in part a was the answer for part b.

Part c

Candidates were expected to understand the relative sensitivity of both CDO and CDO^2 to variation in default probabilities of underlying securities

Common mistakes included:

- Not computing the sensitivity relative to the current probabilities of default of the tranches
- Stating that since junior tranches absorb losses first, that they were more sensitive

QUESTION 11

TOTAL POINT VALUE: 2.25 | **LEARNING OBJECTIVE: C6**

SAMPLE ANSWERS

Part a: 1.25 points

Time	0	1	2	
			$26,450	
		$23,000		
Loss Estimate:	$20,000		$20,700	
		$18,000		
			$16,200	
Assets:	$23,000	$24,150	$25,358	= $24,150 * (1.05)
Expected Loss:	$20,000	$20,500	$21,013	= 26,450* .25 + 20,700* .5 + 16,200* .25
EPD if liquidated:		$0	$273	= (26,450- 25,358) * .25
EPD Ratio:	-	-	1.3%	= 273 / 21,013

Part b: 0.5 point

(26,450 – A) * .25 = 21,013 * .05

A = 22,247

Part c: 0.5 point

Sample 1

EPD Ratio doesn't consider diversification benefit, therefore rating agency capital would be lower, all else equal.

Sample 2

If we assume rating agency is using a VaR approach it would be failing to consider the severity of loss whereas EPD considers severity of loss. This is a potential reason for EPD capital requirement could be higher than the rating agency requirement.

Sample 3

Because rating agency looks at probability of default only whereas EPD includes severity of default in addition to probability of default.

EXAMINER'S REPORT

Candidates were expected to be able to calculate the expected policyholder deficit and understand the assumptions underlying this methodology.

Part a

Candidates were expected to calculate the EPD ratio.

Common mistakes included:

- Omitting the expected policyholder deficit ratio
- Incorrectly simulating the assets
- Incorrectly simulating the losses
- Using assets in the denominator of the EPD ratio
- Not multiplying by the correct or any probability in the numerator of the EPD ratio

Part b

Candidates were expected to calculate the asset needed given a set EPD ratio.

The most common mistake was using an incorrect formula.

Part c

Candidates were expected to know the advantages and disadvantages of using Expected Policyholder Deficit (EPD).

A common mistake was to confuse rating agency capital with regulatory capital (e.g. RBC).

QUESTION 12

TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE: C9**

SAMPLE ANSWERS

Part a: 1 point

Sample 1
[(25-1.25) (1+0.04) – 18] / 127 = 5.28%
Where 127 = (50 + 4 + 444 + 10)/4 is the 99.6% Co-CTE for cyber.

Sample 2
Economic profit = (25-1.25) (1+0.04) – 18 = 6.7 M
Capital = (50 + 4 + 444 + 10)/4 = 127
RAROC = 6.7 / 127 = 5.28%

Sample 3
99.6% CTE considers scenarios 996-1000.
Cyber Co-CTE = (2+10+444+4+50) / 5 = 102 M
Economic profit = (25-1.25) (1+0.04) – 18 = 6.7 M
RAROC = 6.7 / 102 = 6.58%

Part b: 0.5 point

Sample 1
127*0.08 = (25 – 1.25 + RM) * 1.04 – 18
Risk Margin = 3.327 M

Sample 2
Target RAROC = 8%
Economic Profit = 8%*102 = 8.16 M
8.16 M = (25 + Risk Margin – 1.25) * 1.04 – 18
Risk Margin = 1.404 M

Sample 3
Required additional margin = 127*0.08 – 6.7 = 3.46
@time 0 = 3.46/1.04 = 3.3269

Sample 4
Need risk margin X
[Net Income + X * (1 + Interest%)]/ Capital = Target RAROC
(6.7M + X * 1.04) / 127 = 0.08
X = 3.327 M

Sample 5
Target Economic Profit = 127 * 0.08 = 10.16 M
Additional Risk Margin = (10.16 – 6.7) / 1.04 = 3.327 M

Sample 6

Required economic profit = 127*8% = 10.16 million
Assume expenses are variable and losses do not change
Risk margin: R
Expense ratio = 1.25/25 = 0.05
10.16 = (25+R) * (1-0.05) * 1.04 - 18
R = 3.502 million

EXAMINER'S REPORT

Candidates were expected to understand how to assess the performance of a business unit on a risk adjusted basis and how to obtain the appropriate additional risk margin.

Part a

Candidates were expected to know how to calculate the risk capital by using Co-CTE and the economic profit, and then to use it in the RAROC calculation.

Two papers on the syllabus present the Co-CTE method differently. The presentation in "Risk-Adjusted Performance Measurement for P&C Insurers" (Goldfarb) includes those simulations above the selected percentile (in this case the top 4 scenarios), while "Capital Allocation by Percentile Layer" (Bodoff) presents Co-CTE (CoTVaR) using the simulations *at or* above the selected percentile (the top 5 simulations). Both approaches, if carried out correctly, could earn full credit.

Common mistakes included:

- Using undiscounted losses instead of discounted losses in the calculation of economic profit
- Including only 3 losses in the calculation of Co-CTE Cyber Risk (instead of 4 or 5)
- Using the 4 (or 5) worst cyber losses instead of the cyber loss of the worst 4 (or 5) aggregate losses
- Not including investment income on the cash flow obtained at the beginning of the year in the calculation of economic profit
- Using the total risk capital in the calculation of the cyber RAROC instead of the cyber risk capital
- Subtracting losses from the risk capital obtained for the cyber risk
- Including investment income on the risk capital in the calculation of the economic profit

Part b

Candidates were expected to calculate the additional risk margin needed to be charged on the cyber policy to achieve its target RAROC.

If candidates calculated a negative number for additional risk margin correctly based on the (incorrect) results of part a, full credit was awarded for part b.

Common mistakes included:

- Using undiscounted loss instead of discounted loss
- Not including investment income of the risk margin
- Inconsistency of timing in the calculation (e.g., include investment income for the premium and discount loss to time 0)
- Including investment income of allocated capital in the calculation

QUESTION 13

TOTAL POINT VALUE: 2 | **LEARNING OBJECTIVE: C7**

SAMPLE ANSWERS

Sample 1

VaR (98) = at event 5 since 0.565 + 0.242 + 0.1 + 0.043 + 0.03 = 0.98

Event	0-3 Layer Cap	3-7 Layer Cap	7-10 Layer Cap	10-30 Layer Prob (CEP)	10-30 Layer Cap	Total	EQ Share
5	0.207	0.622	0.968	0.6	12	13.797	1
6	0.090	0.269	0.419	0.26	5.2	5,978	0.909
7	0.034	0.104	0.161	0.1	2	2.299	0.811
8	0.014	0.041	0.065	0.04	0.8	0.92	0.75

Prob (5) for 10-30 layer = 0.03 / (0.03 + 0.013 + 0.005 + 0.002) = 0.6
Capital (5) for 10-30 layer = 0.6 * (30 – 10) = 12
EQ Share (6) = 30/33 = 0.909

EQ capital total = 13.797 * 1 + 5.978 * 0.909 + 2.299 * 0.811 + 0.92 * 0.75 = 21.786M

Sample 2

1) 98% VaR: Select 30M as required capital level.

Event	Probability	Cumulative Prob	Loss Amount ($M)
1	0.565	0.565	0
2	0.242	0.807	3
3	0.100	0.907	7
4	0.043	0.950	10
5	**0.030**	**0.980**	**30**
6	0.013	0.993	33
7	0.005	0.998	37
8	0.002	1.000	40

2) Assign Capital by Event for 20 xs 10 layer.

Event	Conditional Exceedance Prob.	Capital in Layer	Allocation
5	0.03/(0.03+0.013+0.005+0.002)=0.6	20	0.6 * 20 = 12
6	0.26	20	5.2
7	0.10	20	2
8	0.04	20	0.8

3) Allocate Event Capital to Earthquake.

Event	Layer (20 xs 10)	Lower Layers Capital (Given)	Total Event Allocation	Earthquake %	Earthquake Capital Allocation
5	12	1.797	13.797	30/30 = 100%	13.797
6	5.2	0.778	5.978	90.91%	5.435
7	2	0.299	2.299	81.08%	1.864
8	0.8	0.12	0.92	75.00%	0.690
				Final Answer =	**21.786**

EXAMINER'S REPORT

Candidates were expected to calculate the amount of allocated capital to the Earthquake peril exposure using the percentile layer methodology.

Common mistakes included:

- Selecting the wrong capital requirement for 98% VaR.
- Omitting the capital for the lower layers or using the wrong numbers from the provided table (3 xs 7 layer for example).
- Only allocating the capital in the lower layers to Earthquake (i.e. not calculating anything for the 20 xs 10 layer)

QUESTION 14

TOTAL POINT VALUE: 1.75 | **LEARNING OBJECTIVE: D1**

SAMPLE ANSWERS

Part a: 1.25 points

Sample 1

Required Equity: 433.33 = 650 / 1.5
Equity inflow at time 0: 433.33 - (1000 – 650 - 300 - C) = 383.33 + C
Equity outflow at time 2: (433.33+650) x 1.04^2 - 650 = 521.73
Commission: -383.33 – C + 521.73 / 1.09^2 = 0 => C = 55.80
Commission % = 55.80/1000 = 5.58%

Sample 2

Required Equity: 433.33 = 650 / 1.5 (0.25)
Equity inflow at time 0: 433.33 - (1000 – 650 - 300 - C) = 383.33 + C
Equity outflow at time 1: (433.33+650) x 1.04^1 - 650 - 433.33= 43.32
Equity outflow at time 2: (433.33+650) x 1.04^1 - 650 = 476.32
Commission: -383.33 – C + 43.32 / 1.09 + 476.32 / 1.09^2 = 0 => C = 57.32
Commission % = 57.32/1000 = 5.73%

Part b: 0.5 point

1) Higher expected losses lead to higher reserves. This leads to higher surplus commitment and leads to higher assets and higher investment income

2) Although investment income will increase, it will not offset the decrease in UW income; net income will decrease.
Also, shareholders need to invest more equity therefore IRR will decrease.
Also, investment yield is less than the cost of capital

EXAMINER'S REPORT

Candidates were expected to demonstrate knowledge of the IRR model: the various insurance, investment, and expense cash flows, the surplus commitments and equity flows, as well as the interaction between these cash flows on investment income and IRR.

Part a

Candidates were expected to calculate surplus commitments, investment income, and equity flows in an IRR equation.

Common mistakes included:

- errors in the equity flows
- errors in the interest accrual
- not expressing the final result as a percent of premium.

Part b

Candidates were expected to understand the interaction between expected losses and contributed surplus and their effect on invested assets, as well as the elements that effect the IRR of an insurance policy.

Common mistakes included:

- Simply mentioning that reserves increased leading to greater investment income
- Simply stating that IRR will decrease without a rationale
- Not stating a definitive effect on the IRR

QUESTION 15

TOTAL POINT VALUE: 3.5 | **LEARNING OBJECTIVE:** D3

SAMPLE ANSWERS

Part a: 1 point

Sample 1

PV[pmt] = 1000 x 0.3 / $(1.04^{1/2})$ + 1000 x 0.65 x $(0.5/1.04+0.35/1.04^2+0.15/1.04^3)$ = $903.69

Opp. Cost = 1000 – 903.69 = $96.31

Sample 2

use most recent WP figure

Time	Premium	Expense	Loss	Net CF
0	45			45
0.5		13.5		-13.5
1			14.625	-14.625
2			10.2375	-10.2375
3			4.3875	-4.3875

PV @ Risk Free Rate = 45 - $13.5/1.04^{0.5}$ - 14.625/1.04 - $10.2375/1.04^2$ - $4.3875/1.04^3$ = 4.334 million

Sample 3

(in millions)

Yr	t	P	E	L_1	L_2
2017	**0**	24			
	0.5		7.2		
2018	**1**	45		7.8	
	1.5		13.5		
	2			5.46	14.625
	3			2.34	10.2375
	4				4.3875

Opp Cost = PV CF @ r_f

P = 24 + 45/1.04

E = $-7.2/1.04^{0.5}$ - $13.5/1.04^{1.5}$

L_1 = $-7.8/1.04 - 5.46/1.04^2$ - $2.34/1.04^3$

L_2 = $-14.625/1.04^2 - 10.2375/1.04^3$ - $4.3875/1.04^4$

Opp Cost = $P+E+L_1+L_2$ = 67.27-19.79-14.63-26.37 = 6.48M

Part b: 0.5 point

Sample 1

Should be more. They should expect to earn more than the risk-free rate for putting their capital at risk.

Sample 2

Expected operating profit should be more than opportunity cost due to higher investment yield.

Part c: 1.5 points

Sample 1

Using the Company's own investment return to discount is not appropriate. A risk-free rate should be used, since the policyholder should not be subject to the investment risk of the insurer. If there is an investment loss, the insurer cannot access the insured to make up the shortfall. So, the insureds are NOT exposed to the inv. risk. They should not get a higher return than risk free rate.

Using return on equity will force the regulator to focus on return on equity instead of rate equity, which is not equitable rate regulation. ROE also requires the insurer to allocate equity in segment, which is an artificial allocation for multiline insurers.

Sample 2

It is unfair to insurer which adopts safer/conservative investments. Assuming same equity and UW cash flows between two insurers A & B. Say A adopts a more conservative investment strategy and earn a lower rate. This means less amount of discounting (or bigger disc factor) under the proposed. Sum of PV of CF is higher, and ROE is higher as a result, more likely deemed excessive by regulator. Rate equity is violated.

ROE measure can be distorted by different premium/surplus ratios across different insurers →rate equity not achieved. Companies A & B have same premiums, expected losses, and expenses. But A has premium/surplus ratio of 3:1 while B has P/S ratio of 1.5:1. Under this proposal, A is deemed to have a much higher ROE than B, which is a distorted/inflated result due to lower surplus held.

Part d: 0.5 point

Sample 1

Use return on sales for rate regulation. It is more intuitive to customers as it can be viewed as a "mark-up" in price as compared to other industries. It will not be impacted by surplus selection which is artificial.

Sample 2

Use return on premium instead of return on equity. It's the concept of markup, which will not be impacted by the amount of surplus/equity held by different company.

Sample 3

Return on sales is a better alternative

- Not distorted by varying degrees of leverage
- Does not require an artificial allocation of surplus
- Results in true rate equity

EXAMINER'S REPORT

Candidates were expected to demonstrate sufficient knowledge in assessing insurer profitability, understand differences in policyholder vs. investor perspectives, and be able to comment on different regulatory frameworks.

Part a

Candidates were expected to calculate the opportunity cost to the insured of Company A and use risk free rate to discount the cash flow.

Although this part prompted candidates to calculate the opportunity cost for **an** insured, a substantial number of candidates used the full written premiums of 2018 or 2017 and 2018 as the base to calculate the opportunity cost, instead of policy premium. Credit was given to such cases if the calculation was correct.

Common mistakes included:

- not using risk free rate
- not including expense in the cash flow
- not following the payout pattern given in the question.

Part b

Candidates were expected to identify that Company A's expected profit should be higher and offer a brief explanation.

A common mistake was to compare company A to company B rather than comparing the expected operating return to the opportunity cost.

Part c

Candidates were expected to identify the drawback of the proposed regulatory framework, make a comparison of Company A and B in the explanation (or companies of different positions), and explain why it does not result in equitable rate regulation.

Using calculations to demonstrate the conclusion was acceptable, but any calculations needed to be accompanied by an explanation.

Common mistakes included:

- not fully supporting one or both reasons
- Including an explanation that doesn't support the reason identified. For example, identifying that one company is penalized but the justifications support otherwise.
- Simply calculating Company A and B's positions without a proper conclusion/explanation.

Part d

Candidates were expected to identify Return on Sales as the preferable basis and offer a brief explanation.

A common mistake was to identify an alternative basis without an explanation for why it is preferable.

QUESTION 16

TOTAL POINT VALUE: 3 | **LEARNING OBJECTIVES: D4, D5**

SAMPLE ANSWERS

Part a: 2.5 points

Sample 1

Risk Adj Rate for Loss = .05 + -.25 (.09 - .05) = 4%
Rf = 5%

T	P	E	L	PV P	PV E	PV L	CF
0	.6p	.06p + 4.5		.63p	.063p + 4.725	0	.567p - 4.725
1	.4p	.14p + 10.5	22	.4p	.14p + 10.5	22	.26p - 32.5
2			33			31.73	-31.73

II Tax = 3 * .21 = .63 (already discounted to time 1)
U/W Tax = .21 * (.567p -4.725 + .26p – 32.5 -31.73) = .17367p – 14.481

1.03p = (.203p+15.225) + 53.73 + .63 + (.17367p – 14.481)
.65333p = 55.104
p= 84.343

84.343 = (55 + 15) / (1 - .2 – U)
67.4744 -84.343U = 70
U = -3%

Sample 2

Rr = .05 - .25 * (.09 - .05) = .04 <- disc. Rate for losses
PV(Prem) = 1.05* .6p + .4p = 1.03p
PV(Loss) = 55 * (.4 + .6/1.04) = 53.73
PV(Expense) = (.2P+ 15) * (.3x1.05 + .7) = .203p + 15.225
PV Tax on II = 3 x .21 = .63

.63 = (1.03p – 53.73 - .203p – 15.225) * (1-.21)
0 = .653p – 54.44 - .63
P= 84.334M

CR = (55 + 15 + 0.2 *84.334)/84.334 = 103%
1-CR = Profit = -3%

Part b: 0.5 point

Sample 1

The company should also consider investment income. If the investment income offsets the UW loss, the line can still be profitable overall.

Sample 2

Not appropriate. The business is still profitable even if U < 0, if the return from investment income is able to offset the UW losses. In Ferrari, as long as (I/A + U/R) > 0, it is okay if U/R < 0.

EXAMINER'S REPORT

Candidates were expected to understand the Risk-Adjusted Discounted Cash Flow Method, calculate a profit provision, and demonstrate their understanding of how the underwriting profit provision relates to total profit.

Part a

Candidates were expected to demonstrate the calculation of the profit provision using the Risk-Adjusted Discounted Cash Flow Method as described in "The Underwriting Profit Provision" (Robbin UW).

Common mistakes included:

- Mistakes in calculating tax on underwriting cash flow
    - Many candidates used undiscounted values, which is inconsistent with the method as presented in Robbin UW
- Setting the PV (Loss + expense + taxes) equal to P instead of the discounted 1.03 P
- Discounting the entire underwriting cash flow (including the losses) at 5%, which is inconsistent with the method as presented in Robbin UW
- Including investment income in the premium calculation (as opposed to just the tax on investment income)
- Using discounted values to calculate the final profit provision in the final step
- Making assumptions that were inconsistent with the information given in the prompt, such as:
    - Calculating and including tax on additional investment income
    - Changing how the underwriting cash flows applied to premium/loss/expense
        - Candidates assuming variable expenses followed the premium payment pattern were not penalized
    - Assuming that taxes were only incurred on period 1 cash flows

Part b

Candidates were expected to indicate that the underwriting profit provision did not include investment income and that the acquisition could be profitable regardless of the sign of the underwriting profit provision. Candidates were not required to perform any calculations or reference the specific profit provision calculated in part a.

Common mistakes included:

- Citing diversification benefits, which would not generally be sufficient to justify making an unprofitable acquisition
- Simply stating that that the method is based on sound economic theory or calculates a "fair premium"
- Suggesting an alternative method to calculate the profit provision
- Requiring a higher rate of return, such as one greater than the cost of capital, without explaining the specific deficiency of using underwriting profit provision
- Identifying that the line could still be profitable without specifically identifying the lack of investment income in the underwriting profit provision

QUESTION 17

TOTAL POINT VALUE: 2 | **LEARNING OBJECTIVE: D5**

SAMPLE ANSWERS

Part a: 1.5 points

t	(1) Earn Prem	(2) Incurred Loss	(3) Incurred Expense	(4) U/W Income	(5) Surplus	(6) Invest. Income	(7) U/W + Inv. Income	(8) After Tax Income
0	1000	0	400	600	500	-------	600	480
1	600	800	20	-220	300	20	-200	-160
2	-----	300	-----	-300	-----	12	-288	-230.4

(4) = (1) – (2) – (3)
(5) = (1) * 0.5
$(6)_t = (5)_{t-1} * (.04)$
(7) = (4) + (6)
(8) = (7) * (1 - .20)

Using given Discount Rate of 10%

$PVI_{t=1}$ = (480 * 1.10) - 160 - (230.4 / (1.1)) = 158.54

$PVE_{t=0}$ = 500 + 300 / 1.10 = 772.73

PVI / PVE = 158.54 / 772.73 = 20.52%

Part b: 0.50 point

- Discount rate used for PVI/PVE is equal to the IRR.
- Growth rate of the company equals the IRR.

EXAMINER'S REPORT

Candidates were expected to know and calculate the parts needed to calculate the PVI/PVE ratio, calculate the PVI/PVE ratio for the company and conditions given, and demonstrate knowledge of what two conditions need to exist for the PVI/PVE % and the Calendar Year ROE % to be equal.

Part a

Candidates were expected to know what is included in the PVI and PVE and:

- Calculate the U/W Income of the policy by time-period.
- Calculate the allocated Surplus
- Calculate the Investment Income to occur at t=1 and t=2
- Calculate the After-Tax Income by time-period for the company
- After calculating the After-Tax Income above, the candidates were expected to calculate the PVI by calculating the PVI at t=1.
- Calculate the PVE at t=0; and calculate the PVI/PVE %.

Common mistakes included:

- Treating the EP and Incurred Expenses as happening at the end of the policy period by applying a GAAP standard for the calculation. The conditions given in the problem were to treat EP and Incurred Expenses as happening at the beginning of the policy term.
- Not calculating the Surplus correctly. Either calculating the Surplus allocated at the beginning of the first policy term as covering both policy terms ([1000 + 600] / 2 = 800); or mis-timing the surplus to the end of the policy term to when they stated the premium was earned.
- Miscalculating when the Investment Income occurs or the amount of the Investment Income.
- After Tax calculation problems occurred by not applying the tax calculation if the Income was negative; or not applying the tax rate to both the U/W income and the Interest Income.
- Not discounting the PVI correctly to t=1; or not discounting the PVE correctly to t=0.
- Calculating a Deferred Acquisition Costs (DAC) component and adding it into the surplus in the PVE calculation.

Part b

Candidates were expected to demonstrate the knowledge that if the PVI and PVE discount using the IRR and the constant growth rate equals the IRR, then the two models will produce the same results: i.e. the PVI/PVE % will equal the Calendar-Year ROE %.

A common mistake was not stating the PVI/PVE discount rate or Growth rate (g) must equal the IRR. Simply stating "…the PVI/PVE has to equal the growth rate" was not sufficient to receive full credit.

QUESTION 18

TOTAL POINT VALUE: 2.25 | **LEARNING OBJECTIVE: D7**

SAMPLE ANSWERS

Part a: 1.25 points

Sample 1

Order	Entity 1	Entity 2	Entity 3
123	1,900,000	2,600,000	4,200,000
132	1,900,000	2,300,000	4,500,000
213	1,300,000	3,200,000	4,200,000
231	1,200,000	3,200,000	4,300,000
312	1,300,000	2,300,000	5,100,000
321	1,200,000	2,400,000	5,100,000
Average	**1,466,667**	**2,666,667**	**4,566,667**

Sample 2

Entities 1 and 2 save .6M by combining (=1.9+3.2-4.5)
Entities 1 and 3 save .6M
Entities 2 and 3 save .8M

Savings are shared equally:
Entity 1 saves .3+.3=.6
Entity 2 saves .3+.4=.7
Entity 3 saves .3+.4=.7
Sum of savings = .6+.7+.7 = 2.0

But this overstates total savings of 8.7-1.9-3.2-5.1=1.5
Equally, all 3 must contribute (2.0-1.5)/3=.167 extra

Entity 1 = 1.9-.6+.167=1.467
Entity 2 = 3.2-.7+.167=2.667
Entity 3 = 5.1-.7+.167=4.567

Part b: 0.5 point

One of the following:

- Individual Rationality: any entity cannot be worse off when joining group
- No individual should be better off by themselves
- Each member should not benefit from leaving the group
- Must not exceed capital needed for single entry
- Company should not pay more than its stand-alone required fund
- Each party must benefit from the overall arrangement

And one of the following:

- Collective Rationality: no subgroup can be better off on its own
- Required funds must be at least the marginal impact from joining the group
- Other parties do not have incentive to leave

Part c: 0.5 point

Sample 1

Stand alone: 3.2M
Marginal: 8.7 - 6.4 = 2.3M
->between 2.3M and 3.2M

Sample 2

2.3-3.2

EXAMINER'S REPORT

Candidates were expected to use the Shapley method to determine required funds and understand conditions of rationality in relation to game theory.

Part a

Candidates were expected to use the Shapley method to determine the amount each individual entity would contribute to the required funds to form a single company. Candidates were expected to understand that the Shapley value is the average of the marginal impacts taken over all possible entrance permutations. Other mathematically equivalent approaches could be taken, which involved sharing the savings equally among entities.

Common mistakes included:

- Allocation of required funds which did not add up to the total combined funds for the combined entities 1&2&3 (8.7M)
- Merely splitting the overall marginal impact equally or proportionally amongst the entities
- Attempting to calculate and split the savings equally, but using methods which did not result in the Shapley allocation
- Missing one or more of the six entrance permutations
- Averaging over the wrong entrance permutations
- Incorrect marginal impact for one or more entrance permutations
- Calculation errors in determining the marginal impacts

Part b

Candidates were expected to describe the two conditions of rationality relating to game theory: individual rationality and collective rationality.

Common mistakes included:

1. Stating "stable", "fair", or "must be equitable" without explaining how they relate to the conditions of rationality
2. Reversing the descriptions for individual and collective rationality
3. Simply identifying, but failing to provide a description of, one or both conditions

Part c

Candidates were expected to determine the range of funds contributed for Entity 2 that satisfy the conditions of rationality. Candidates were expected to understand that the upper bound is the stand-alone fund requirement and the lower bound is the total combined requirement for the three minus the requirement for entities 1&3 to form their own company.

Common mistakes included:

1. Selecting Entity 2's required funds from part a. as the lower bound
2. Selecting the stand-alone requirement as the lower bound instead of the upper bound

QUESTION 19	
TOTAL POINT VALUE: 1.25	**LEARNING OBJECTIVE: D6**
SAMPLE ANSWERS	

Risk Load = 1.25 * ((100 +93 + 88 + 81 + 77) – 5 * 50) / 0.005 = 47.25

Capital =Expected Loss + Risk Load = 50 + 47.25 = 97.25 (in 000's)

EXAMINER'S REPORT

Candidates were expected to know the formula relating observations of a risk distribution to required capital. In this case first calculating the risk load and then required capital.

Common mistakes included:

- Calculating risk load only
- Using the wrong set of simulations
- Using the wrong number of simulations.
- Failing to divide by frequency = 0.005
- Failing to subtract out expected loss in calculation of risk load
- Including an extra factor (often "5") in the formula
- Not including factor of 1.25
- Using something other than expected loss = 50
- Various calculator errors between setting up the formula and the final answer.