Exam 7

CASUALTY ACTUARIAL SOCIETY
AND THE
CANADIAN INSTITUTE OF ACTUARIES

Exam 7

Estimation of Policy Liabilities, Insurance Company Valuation, and ERM

April 24, 2015

4 HOURS

INSTRUCTIONS TO CANDIDATES

1. This 62.25 point examination consists of 29 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, 7, at the top of each answer sheet. 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 specific number of items is requested, do not offer more items than the number requested. For example, if three items are requested, 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.

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.

CONTINUE TO NEXT PAGE OF INSTRUCTIONS

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. Anything written in the examination booklet will not 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 15, 2015.

END OF INSTRUCTIONS

1. (2.25 points)

Given the following information:

Incremental Paid Claims ($000)

Accident Year	0-12 Months	12-24 Months	24-36 Months	Earned Premium
2012	2,400	1,000	400	5,000
2013	2,700	900		5,200
2014	2,100			5,400

a. (1.75 points)

Use the Neuhaus credibility weight to estimate the unpaid claim liability for accident year 2014 as a linear combination of R^{ind} and R^{coll}.

b. (0.5 point)

Assuming that $Var[U_i] = Var[U_i^{BC}]$ and using Hürlimann's method for optimal credibility and minimum variance, estimate the unpaid claim liability for accident year 2014.

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2. (2.5 points)

Given the following paid claim information as of December 31, 2014:

Accident Year	Paid Claims ($000)
2011	12,000
2012	11,250
2013	14,750
2014	9,500
Total	47,500

- The expected paid claim emergence pattern has been approximated by the following function where G is the cumulative proportion of ultimate claims paid and x represents the average time since accident occurrence in months.

$$G(x) = \frac{x}{x + 10}$$

- The expected incremental paid claim emergence follows an over-dispersed Poisson distribution with scaling factor $\sigma^2 = 25{,}000$.
- Parameter standard deviation for the total estimated unpaid claims is $850,000.

a. (2 points)

Using a truncation point of 10 years, calculate the coefficient of variation of the total unpaid claims using the LDF method.

b. (0.5 point)

Identify the direction in which the coefficient of variation of the total unpaid claims estimate would change if the method used to calculate the unpaid claims estimate were changed from the LDF method to the Cape Cod method, and briefly explain the reason it would change in this direction.

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3. (2.25 points)

Given the following information:

Cumulative Reported Claims ($000)

Accident Year	As of 12 Months	As of 24 Months
2008	1,700	3,600
2009	2,300	3,200
2010	1,200	1,700
2011	500	2,600
2012	2,600	3,000
2013	700	2,100

a. (1.5 points)

Calculate the weighted residuals for reported claims as of 24 months following Mack's methodology. Create a scatter plot of these residuals against cumulative reported claims as of 12 months.

b. (0.75 point)

Identify which one of the three assumptions specified by Mack as underlying the chain ladder method can be tested by reviewing the scatter plot created in part a. above, and discuss whether the assumption has been violated.

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4. (3.5 points)

Given the following information:

Age-to-Age Paid Loss Development Factors

Accident Year	12-24 Months	24-36 Months	36-48 Months	48-60 Months	60-72 Months	72-84 Months
2008	7.00	2.55	1.60	1.30	1.20	1.05
2009	6.00	2.60	1.40	1.50	1.10	
2010	5.00	2.50	1.80	1.20		
2011	5.50	2.80	1.50			
2012	8.00	2.40				
2013	7.00					

- z-value for the 95% confidence level: ±1.96

a. (3 points)

Using a 95% confidence threshold, test the null hypothesis that the triangle does not display significant calendar year effects.

b. (0.5 point)

Provide two examples of calendar years effects that may cause loss development data not to be independent by accident year.

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5. (2.5 points)

Given the following information:

Age-to-Age Loss Development Factors

Accident Year	12-24 Months	24-36 Months	36-48 Months	48-60 Months	60-72 Months
2009	2.50	1.45	1.06	1.05	1.01
2010	1.80	1.38	1.15	1.02	
2011	2.13	1.20	1.13		
2012	2.18	1.36			
2013	1.95				

Degrees of Freedom	t-statistic for 0.9
1	3.078
2	1.886
3	1.638
4	1.533
5	1.476
6	1.440

Assume that $T = r \cdot [(n-2)/(1-r^2)]^{1/2}$ is t-distributed with $(n-2)$ degrees of freedom, where r is the sample correlation coefficient.

Using Mack's correlation test with a 10% t-statistic significance standard, test the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent.

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6. (2.75 points)

Given the following information for a book of workers compensation business:

Reported Losses ($000) – $250,000 Per-Occurrence Limit

Accident Year	12 Months	24 Months	36 Months	48 Months
2011	6,000	8,472	11,642	12,860
2012	5,620	8,748	12,156	
2013	6,482	9,598		
2014	6,216			

Reported Losses ($000) – $1,000,000 Per-Occurrence Limit

Accident Year	12 Months	24 Months	36 Months	48 Months
2011	6,798	12,041	19,888	24,106
2012	5,823	10,541	17,896	
2013	7,321	13,877		
2014	6,984			

2014 earned premium	$44,622,000
Expected loss ratio assumed in pricing	60%
Industry per-occurrence charge at $250,000	0.47
Industry per-occurrence charge at $1,000,000	0.05
Increased limit factor from basic limit to $250,000	1.21
Increased limit factor from basic limit to $1,000,000	2.27

- Losses are fully developed at 48 months.
- Ratio of reported losses limited to $250,000 per occurrence to reported losses limited to $1,000,000 per occurrence is given by $y =$ (ultimate ratio) $e^{0.177t}$ where t is the time to ultimate maturity, measured in years.

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(6 continued)

a. (0.5 point)

Using Siewert's loss ratio approach, estimate ultimate losses in the layer between $250,000 and $1,000,000 for accident year 2014.

b. (1.25 points)

Using Siewert's implied development approach, estimate ultimate losses in the layer between $250,000 and $1,000,000 for accident year 2014.

c. (1 point)

By adjusting the loss development factors for losses limited to $1,000,000 per occurrence to apply to losses in the layer between $250,000 and $1,000,000, calculate ultimate losses in the layer between $250,000 and $1,000,000 for accident year 2014.

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7. (1.5 points)

An insurer writes Personal Automobile and Homeowners insurance in multiple geographic locations.

Identify three questions an actuary could ask company management to help determine how to segment the claims portfolio into appropriate classes for estimating unpaid claims liabilities. For each question, briefly explain why it should be asked.

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8. (3.5 points)

An insurer writes the following lines of business and has derived the associated coefficients of variation (CoV) for claim liabilities for the purpose of determining a risk margin.

Line of Business	Claim Liability Distribution	Internal Systemic Risk CoV	External Systemic Risk CoV	Independent Risk CoV
Personal Auto	60%	5%	4%	5%
Commercial Auto	35%	7%	5%	5%
Commercial Umbrella	5%	15%	10%	7%

- The insurer will only write umbrella over its own commercial auto policies.
- The insurer used a balanced scorecard approach for internal systemic risk.

a. (1.5 points)

Describe two sources of internal systemic risk. Briefly explain why each one might lead to a higher CoV selection for umbrella than for the other two lines of business.

b. (0.75 point)

Identify a source of external systemic risk with a relatively *high* correlation between two of the above lines of business. Name the two lines and provide a brief reason for the high correlation.

c. (0.75 point)

Identify a source of external systemic risk with a relatively *low* correlation between two of the above lines of business. Name the two lines and provide a brief reason for the low correlation.

d. (0.5 point)

Assuming independence, calculate the independent risk CoV for the overall portfolio.

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9. (1.5 points)

Given the following portfolio characteristics and selected coefficients of variation (CoV):

			Selected Coefficients of Variation (CoV)	
Portfolio	Portfolio Size ($000,000)	Length of Claim Run Off (in years)	Outstanding Claim Liability	Premium Liability
A	50	20	5.5%	y
B	300	20	x	7.0%
C	300	5	0.5%	0.3%

- Event risk is not material.

a. (0.75 point)

Select a value for x and explain why it is reasonable within the scope of internally benchmarking independent risk.

b. (0.75 point)

Select a value for y and explain why it is reasonable within the scope of internally benchmarking independent risk.

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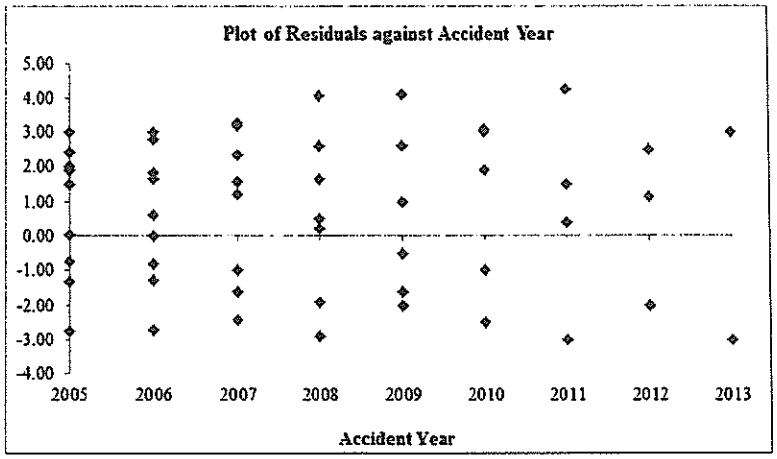
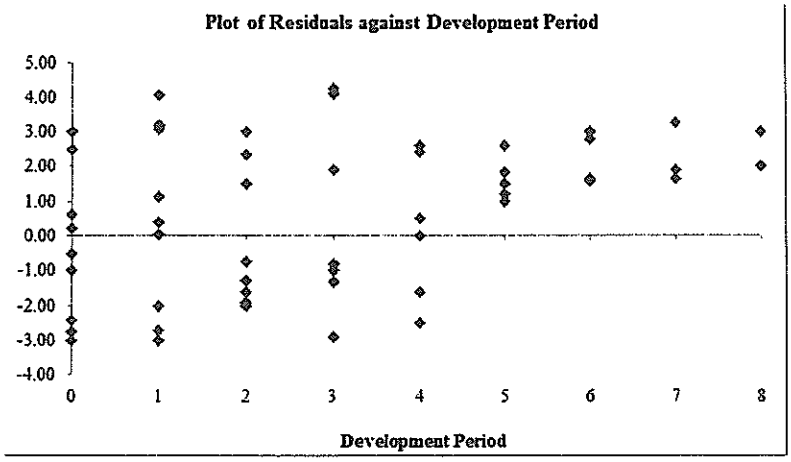
10. (2 points)

Given the following residual graphs from an over-dispersed Poisson (ODP) bootstrap model:





a. (0.5 point)

For each graph, briefly discuss whether the illustrated residuals demonstrate the presence or absence of heteroscedasticity.

b. (0.5 point)

Describe why it is important to adjust for heteroscedasticity when using a bootstrap model.

c. (1 point)

Describe two procedures for adjusting for heteroscedasticity.

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11. (1.5 points)

An insurer is doing bootstrapping using a GLM with a log-link function and an over-dispersed Poisson error function on the following dataset of incremental reported loss values ($000).

Year	Age 1	Age 2	Age 3	Age 4	Age 5
1	50	100	0	0	0
2	250	450	200	50	0
3	300	500	250	-20	0
4	250	1,000	100	-50	
5	300	500	250		
6	350	400			
7	300				

a. (0.25 point)

Identify an issue with the data that would cause model failure if left unadjusted.

b. (0.5 point)

Identify two additional issues with the data that may impact modeling results.

c. (0.75 point)

For each of the three issues identified in part a. and part b. above, briefly describe how the data might be adjusted to improve modeling results.

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12. (1 point)

Given the following ground-up information for insurance claims subject to a single excess-of-loss reinsurance treaty as of December 31, 2014:

Claim Number	Occurrence Number	Date of Loss	Reported ALAE	Reported Loss	Total Reported Loss and ALAE
1	1	Feb 29, 2013	$12,000	$80,000	$92,000
2	2	May 28, 2013	18,000	145,000	163,000
3	3	Sep 5, 2013	8,000	70,000	78,000
4	3	Sep 5, 2013	3,250	30,000	33,250
5	4	Jan 24, 2014	9,000	90,000	99,000
6	5	Mar 7, 2014	20,000	225,000	245,000
7	6	Oct 18, 2014	3,750	55,000	58,750

Accident Year	Historical Per-Occurrence Retention
Jan 1, 2013 – Dec 31, 2013	$150,000
Jan 1, 2014 – Dec 31, 2014	200,000

- The historical pre-occurrence retentions apply to combined loss and ALAE.
- The reinsurance treaty stipulates that the reinsurer must be notified of any occurrences whose reported loss and ALAE reaches 50% of the retention.

Demonstrate how the data above indicates the presence of two aspects of reinsurance loss reserving that make it somewhat more difficult than primary loss reserving.

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13. (1.75 points)

Given the following information for a reinsurer as of December 31, 2014 ($000):

Accident Year	Earned Premium	Earned Risk Pure Premium	Adjusted Premium	Aggregate Reported Loss	Aggregate Loss Report Lag
2011	10,000	10,000	9,000	6,000	90%
2012	11,500	11,000	12,000	5,000	70%
2013	12,500	12,000	11,000	2,000	40%
2014	14,000	13,000	13,000	4,000	30%

a. (1.25 point)

Using the Stanard-Bühlmann Method, estimate the IBNR for all accident years combined.

b. (0.5 point)

Identify and briefly explain the need for the modification made to earned risk pure premium to derive adjusted premium.

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14. (2.5 points)

Given the following information:

Basic premium factor	0.20
Loss conversion factor	1.20
Tax multiplier	1.05
Loss capping ratio (first adjustment)	85%
Incremental loss capping ratio (second adjustment)	60%
Expected loss ratio	75%
Percent of loss emerged at first adjustment	80%

a. (1.25 points)

Calculate the premium development to loss development (PDLD) ratios for the first and second premium adjustments.

b. (0.5 point)

Briefly explain two benefits of using the retrospective rating formula method over using historical data when calculating the PDLD ratio.

c. (0.75 point)

Assuming all claims are greater than the plan minimum, explain how a push to settle small claims faster would impact PDLD ratios.

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15. (2.25 points)

Given the following forecasted information for a company ($000):

	2016	2017	2018
Beginning GAAP Equity	100,000	105,000	107,000
Net Income	10,000	12,000	13,000
Minimum Capital Requirement	105,000	107,000	110,000

- Investors demand 8% return on equity.

a. (1.25 points)

Assuming 3% growth in abnormal earnings in perpetuity, calculate the company value as of January 1, 2016.

b. (0.5 point)

Assuming abnormal earnings grow 3% for 3 years beyond the forecast horizon, and then decrease to $0 for 2022 and all subsequent years, calculate the company value as of January 1, 2016.

c. (0.5 point)

Discuss which of the two scenarios presented above is more realistic.

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16. (1.5 points)

The discounted cash flow (DCF) method for company valuation relies on the estimation of free cash flows.

a. (0.75 point)

Define free cash flow.

b. (0.25 point)

Briefly explain a practical weakness with the estimation of free cash flows.

c. (0.5 point)

Explain how the abnormal earnings method represents an improvement over the DCF method.

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17. (3.5 points)

Given the following financial projections for a company as of December 31, 2014:

Year	After-Tax Net Income ($000)
2015	15,200
2016	16,100
2017	17,300
2018	18,500

Dividend payout ratio	60% of after-tax income
Company ROE	10.0%
Risk-free rate	3.2%
Market risk premium	4.0%
Company beta	0.75
Industry beta	0.89
Industry average growth rate	5.5%

a. (2.25 points)

Use the dividend discount model to value this company as of December 31, 2014.

b. (0.5 point)

Briefly describe two considerations when using an industry beta.

c. (0.75 point)

Assess the reasonableness of the company beta.

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18. (2 points)

The International Actuarial Association's *A Global Framework for Insurer Solvency Assessment* outlines the following procedure for simulating underwriting losses for a multi-line insurer:

1. For each line of insurance i:
   a. Select a random number χ_i from a gamma distribution with mean 1 and variance c_i.
   b. Select a random claim count K_i from a Poisson distribution with mean $\chi_i \lambda_i$ where λ_i is the expected claim count for line of insurance i.
   c. For each i and for $k = 1,\ldots,K_i$, select a random claim size, Z_{ik}, from a lognormal distribution with mean μ_i and standard deviation σ_i.
2. Set $X_i = \sum_{k=1}^{K_i} Z_{ik}$ = Loss for line of insurance i.
3. Select a random number p, from a uniform (0, 1) distribution. For each line i, select β_i to be the p^{th} percentile of a distribution with $E[\beta_i] = 1$ and $Var[\beta_i] = b_i$.
4. Set $X = \sum_i \beta_i \cdot X_i$ = Loss for the insurer.

This results in the following formula for the variance of a line's loss ratio (losses divided by expected losses):

$$Var\left[\frac{\beta_i \cdot X_i}{E[\beta_i \cdot X_i]}\right] = (1 + b_i)\left(\frac{\mu_i^2 + \sigma_i^2}{\lambda_i} + c_i\right) + b_i$$

a. (0.5 point)

Derive a formula for the minimum variance of a line's loss ratio for the model described above.

b. (0.25 point)

Briefly explain the significance of the result from part a. above for the estimation of an insurer's underwriting risk within any single line of business.

c. (0.25 point)

Identify the correlation affected by the parameter c_i above.

d. (0.25 point)

Identify the correlation affected by the parameter b_i above.

e. (0.75 point)

For a particular line of business, the standard deviation of the loss ratio can be no smaller than 30%. In addition, the standard deviation of inflationary effects is estimated at 4%. Determine estimates of b and c for this line of business.

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19. (1.25 points)

A monoline property insurance company writing business exclusively in the U.S. requires catastrophe reinsurance in order to remain within acceptable levels of risk tolerance. The company is considering two different reinsurance options from reinsurers willing to write 100% of the risk for the same price.

- Reinsurer A has $10 billion of surplus, writes primarily U.S. property reinsurance and has the highest possible financial strength ratings.
- Reinsurer B has $10 billion of surplus, writes primarily casualty reinsurance and has the highest possible financial strength ratings.

a. (0.75 point)

Explain how the risk level differs between the two options and how that might impact the required surplus as measured by the company's capital model.

b. (0.5 point)

Explain why placing 100% of the coverage with one reinsurer may lead to a suboptimal use of capital for the company.

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20. (3 points)

Given the following information for an insurer's gross aggregate loss distribution:

Expected value	$20,000,000
90% VaR	$50,000,000
Limited expected value at $50,000,000	$8,000,000

- The capital requirement is set at 90% TVaR.

The insurer is evaluating the impact of two reinsurance options from a reinsurer that has received a B credit rating from a widely recognized rating agency. Assume a 60% charge for reinsurance recoverable credit risk associated with this reinsurer.

Option 1

- Excess-of-loss reinsurance
- Attachment $50,000,000
- Limit $100,000,000
- Expected ceded loss $7,500,000

Option 2

- Quota share reinsurance
- 40% ceding percentage
- No ceding commission

a. (1.25 points)

Calculate the net capital requirement for the insurer if Option 1 is purchased.

b. (0.75 point)

Calculate the net capital requirement for the insurer if Option 2 is purchased.

c. (0.5 point)

Briefly describe two challenges of assessing the impact of reinsurance on the insurer's risk profile.

d. (0.5 point)

Briefly describe two ways the insurer may be able to lower its reinsurance recoverable credit risk exposure.

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21. (1 point)

a. (0.5 point)

Briefly describe two benefits of using copulas to express correlation from joint loss distributions.

b. (0.5 point)

Identify a copula that is more appropriate than the normal copula for modeling insurance loss at the portfolio level, and briefly describe a feature of this copula that makes it more appropriate than the normal distribution for modeling insurance loss data.

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22. (2.25 points)

An actuary is modeling the variability of an insurer's homeowners ultimate losses for the next accident year as part of an internal solvency model.

a. (1.5 points)

Identify and briefly explain three key elements of uncertainty inherent to the loss modeling process.

b. (0.75 point)

The actuary uses a normal distribution to model the losses, with the parameters selected using five years of internal loss history. The actuary has just learned of a recent court ruling affecting homeowners coverage triggers in the state where the insurer writes the most premium.

For each of the three elements of uncertainty identified in part a. above, suggest an improvement to the actuary's modeling process that would decrease the overall uncertainty in modeled losses.

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23. (2.75 points)

Given the following ultimate loss estimates for a single line of business of an insurer operating in two states ($000,000):

Accident Year	State A	State B
2010	15	30
2011	19	23
2012	22	27
2013	18	28
2014	37	45

a. (1.5 points)

Calculate the Pearson product-moment correlation between the losses from the two states.

b. (0.75 point)

Calculate Spearman's ρ correlation between the losses from the two states.

c. (0.5 point)

Explain the apparent discrepancy between the two correlation measures calculated above.

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24. (2.25 points)

For each of the risk measures identified below, provide a definition and explain one significant limitation of the measure in the context of an ERM application.

a. (0.75 point)

Value at Risk (VaR)

b. (0.75 point)

Tail Value at Risk (TVaR)

c. (0.75 point)

Risk-adjusted TVaR (RTVaR)

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25. (2 points)

a. (0.5 point)

Define each of the following:
i. Insurance underwriting risk
ii. Liquidity risk

b. (0.75 point)

Identify an event scenario that illustrates comovement of insurance underwriting risk and liquidity risk. Briefly describe how the potential for this scenario could affect the assessment of these two risk types.

c. (0.75 point)

Identify a risk mitigation strategy for the scenario identified in part b. above. Briefly describe how this strategy would reduce each component of risk considered here.

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26. (2.5 points)

A primary insurance company is evaluating two reinsurance options. The company estimated the following information from its modeled probability distribution of underwriting results.

	Gross	Option 1	Option 2
Probability of Distress	3.00%	0.70%	0.65%
1-in-250 VaR Loss ($000,000)	530	130	130
1-in-100 TVaR Loss ($000,000)	570	220	210
Expected Net Underwriting Profit ($000,000)	70	37	30

Cost of Risk Capital	10%
Required Risk Capital	1-in-100 TVaR

a. (1.5 points)

For each of the three risk measures provided, perform an efficient frontier analysis to determine whether either of the reinsurance options under consideration is superior to the other.

b. (1 point)

Using the cost of allocated risk capital method, determine which reinsurance option is preferable for the insurance company.

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27. (1.5 points)

a. (1 point)

Describe two consequences of financial distress for insurance companies.

b. (0.5 point)

Briefly describe two reasons why mutual insurance companies tend to purchase more reinsurance than publicly owned insurance companies.

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28. (1 point)

    a. (0.5 point)

    Contrast operational risk with strategic risk.

    b. (0.5 point)

    Identify two strategic risks to which an insurance company is exposed.

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29. (2.5 points)

Given the following characteristics of two insurance companies writing business exclusively in the U.S.:

	Insurance Company A	Insurance Company B
Lines Written	Homeowners	Auto Liability, General Liability
States Operating	Florida	All 50 states
Invested Assets	U.S. equities only	Foreign equities and foreign bonds only
Credit Rating	Strong with negative outlook	Strong with stable outlook
Reinsurance Used	Quota Share	Excess of Loss
Employee Count	50	300

a. (2 points)

Identify four sources of risk that the two insurers face to different degrees and for each source identified, briefly contrast the two insurers' risk.

b. (0.5 point)

Propose two changes that Insurance Company A can make to reduce its risk profile

END OF EXAMINATION

Exam 7

Estimation of Policy Liabilities, Insurance Company Valuation, and ERM

POINT VALUE OF QUESTIONS

QUESTION	VALUE OF QUESTON	SUB-PART OF QUESTION (a)	(b)	(c)	(d)	(e)	(f)	(g)
1	2.25	1.75	0.50					
2	2.50	2.00	0.50					
3	2.25	1.50	0.75					
4	3.50	3.00	0.50					
5	2.50	2.50						
6	2.75	0.50	1.25	1.00				
7	1.50	1.50						
8	3.50	1.50	0.75	0.75	0.50			
9	1.50	0.75	0.75					
10	2.00	0.50	0.50	1.00				
11	1.50	0.25	0.50	0.75				
12	1.00	1.00						
13	1.75	1.25	0.50					
14	2.50	1.25	0.50	0.75				
15	2.25	1.25	0.50	0.50				
16	1.50	0.75	0.25	0.50				
17	3.50	2.25	0.50	0.75				
18	2.00	0.50	0.25	0.25	0.25	0.75		
19	1.25	0.75	0.50					
20	3.00	1.25	0.75	0.50	0.50			
21	1.00	0.50	0.50					
22	2.25	1.50	0.75					
23	2.75	1.50	0.75	0.50				
24	2.25	0.75	0.75	0.75				
25	2.00	0.50	0.75	0.75				
26	2.50	1.50	1.00					
27	1.50	1.00	0.50					
28	1.00	0.50	0.50					
29	2.50	2.00	0.50					
TOTAL	62.25							

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

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 often resulted in the deduction of points where the calculations could not be followed or were not sufficiently supported.
- 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.
- Graders made a good-faith effort to read all responses, but occasionally candidates earned no credit where their responses were illegible.
- Some candidates provided lengthy responses to a "briefly describe" question, which does not earn further credit, but instead takes up additional time during the exam.
- Generally, candidates were fairly well prepared for this exam. However, candidates should be cautious of relying solely on study manuals, as some candidates lost credit for failing to provide basic insights and content contained in the syllabus readings.

EXAM STATISTICS:

- Number of Candidates: 459
- Available Points: 62.25
- Passing Score: 46.75
- Number of Passing Candidates: 224
- Raw Pass Ratio: 48.8%
- Effective Pass Ratio: 49.8%

QUESTION 1

TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE:** A1: Calculate unpaid claim estimates using credibility models.

SAMPLE ANSWERS (BY PART, AS APPLICABLE)

Part a: 1.75 points

Sample Answer 1

$m_1 = 7{,}200 / 15{,}600 = 0.462$
$m_2 = 1{,}900 / (5{,}000 + 5{,}200) = 0.186$
$m_3 = 400 / 5{,}000 = 0.080$
$m_{tot} = 0.462 + 0.186 + 0.080 = 0.728$

$p_1 = m_1 / m_{tot} = 0.462 / 0.728 = 0.634$
$q_1 = 1 - p_1 = 0.366$

$R^{ind} = q_1 / p_1 \times C_{1,3}$
$= 0.366 / 0.634 \times 2{,}100 = 1{,}212$

$R^{coll} = q_1 \times U^{BC}$
$= q_1 \times m_{tot} \times V_1$
$= 0.366 \times 0.728 \times 5{,}400 = 1{,}438$

$Z^{WN} = m_1 = 0.462$
$R^C = Z^{WN} \times R^{ind} + (1 - Z^{WN}) \times R^{coll}$
$= 0.462 \times 1{,}212 + (1 - 0.462) \times 1{,}438 = 1{,}333$

Sample Answer 2

k	m_k	$p_k = m_k / ELR$	$Z^{WN} = p_1 * ELR$
1	(24+27+21)/(50+52+54) = 0.462	.462/.728 = .634	0.634 * .728 = 0.462
2	(10+9)/(50+52)=.186		
3	4/50=.08		

$R^{coll} = 5{,}400 * (m_2 + m_3) = 5{,}400 * (0.186 + 0.08) = 1{,}438$
$R^{ind} = 2{,}100 * (m_2 + m_3)/m_1 = 2{,}100 * (0.186 + 0.08)/0.462 = 1{,}212$
$R^C = Z^{WN} \times R^{ind} + (1 - Z^{WN}) \times R^{coll}$
$= 0.462 \times 1{,}212 + (1 - 0.462) \times 1{,}438 = 1{,}333$

Part b: 0.5 point

Sample Answer 1

$Z^* = p_1 / (p_1 + \sqrt{p_1}) = 0.634 / (0.634 + \sqrt{0.634}) = 0.443$
$R^C = Z^* \times R^{ind} + (1 - Z^*) \times R^{coll} = 0.443 \times 1{,}212 + (1 - 0.443) \times 1{,}438$
$= 1{,}338$

Sample Answer 2

$LDF = 1/p_k = 1/0.634 = 1.577$
$Z^* = (1/1.577) / ((1/1.577) + \sqrt{(1/1.577)}) = 0.443$
$R^C = Z^* \times R^{ind} + (1 - Z^*) \times R^{coll} = 0.443 \times 1{,}212 + (1 - 0.443) \times 1{,}438$
$= 1{,}338$

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

EXAMINERS' REPORT

Candidates were expected to calculate the credibility-weighted reserves using both optimal credibility and Neuhaus credibility. The majority of candidates received full credit and demonstrated a clear understanding of the learning objectives. Of candidates who did not receive full credit, the errors were minor and included:

- Errors in the calculation (set up appears correct but calculation is wrong)
- Selecting the wrong credibility (Z was used for part a)
- Using the chain ladder approach to calculate R^{ind} & R^{coll}

These errors were more common in part a, as part b used the calculations from part a. Candidates understood the topic thoroughly.

Part a

The majority of candidates achieved full credit on this problem or made minimal errors. The candidate was expected to know how to calculate the estimated unpaid claim liability using the Neuhaus credibility. To accomplish this, they needed to perform the following:

- Calculate R^{ind} (need to correctly derive m_1, ELR, p)
- Calculate R^{coll} (need to correctly derive m_1, ELR, p)
- Calculate Neuhaus credibility
- Understand which estimate is the complement of credibility

Most candidates received full credit. The most common error was to incorrectly derive R^{ind} and R^{coll} using the chain ladder method. Other errors included:

- Incorrectly calculating R^{coll} as $U^{BC} – C_{1,3}$
- Weighting ultimates and then subtracting paid losses
- Applying the wrong credibility weights to R^{ind} and R^{coll}

Part b

The majority of candidates received full credit for this problem. The candidates were expected to recalculate the estimate of unpaid claim liability using optimal credibility instead of Neuhaus credibility estimate. They were expected to understand:

- Optimal Credibility
- Which estimate is the complement of credibility

Most candidates obtained full credit. One of the few errors seen was to use an incorrect credibility formula. Another was to write the correct formula but use a different value than p_1 in calculating credibility (such as m_1).

QUESTION 2

TOTAL POINT VALUE: 2.5

LEARNING OBJECTIVE: A2: Estimate parameters and unpaid claims using claims development models related to loss reserving methods such as chain ladder, Cape Cod, chain ladder plus calendar-year effects, Bornhuetter-Ferguson; A3: Calculate the moments and percentiles of unpaid claim distributions implied by the models.

SAMPLE ANSWERS

Part a: 2 points

Sample Answer 1

Accident Year	Paid Losses	Maturity	G(x)	Fitted LDF	Truncated Fitted LDF	Estimated Ultimate Losses	Estimated Unpaid Claims
		114	0.919	1.088	1.000		
2011	$12,000	42	0.808	1.238	1.138	$13,659	$1,659
2012	$11,250	30	0.750	1.333	1.226	$13,790	$2,540
2013	$14,750	18	0.643	1.556	1.430	$21,094	$6,344
2014	$9,500	6	0.375	2.667	2.452	$23,290	$13,790
Total	$47,500					$71,834	$24,334

Note: All substantial values are in 000s

Maturity =	Age of AY – 6	
G(x) =	x / (x + 10)	= given
Fitted LDF =	1 / G(x)	
Truncated LDF =	G(114) / G(x)	
Ultimate Loss =	Paid Loss x Truncated LDF	
Unpaid Loss =	Ultimate Loss – Paid Loss	
Scaling factor =	σ^2 = 25	= given
Parameter SDev =	850	= given
Process variance =	608,343	= σ^2 x Reserves = 25 x 24,334
Process SDev =	780	= $\sqrt{Process\ Variance}$
Parameter variance =	722,500	= (Parameter SDev)^2 = (850)^2
Total Variance =	1,330,843	= Process variance + Parameter variance
Total SDev =	1,154	= $\sqrt{Total\ Variance}$
Process CV =	4.74%	= SDev / Reserves = 1,154 / 24,334

Sample Answer 2

$X_{truncated}$ = 12 x 10 – 6 = 114

G(114) = 114 / (114 + 10) = 0.919

Accident Year	Paid Losses	Maturity	G(x)	Estimated Ultimate Losses	Estimated Unpaid Claims
2011	$12,000	42	0.808	$13,649	$1,649
2012	$11,250	30	0.750	$13,785	$2,535
2013	$14,750	18	0.643	$21,081	$6,331

2014	$9,500	6	0.375	$23,281	$13,781
Total	$47,500			$71,834	$24,296

Note: All dollar values above are in 000s

Ultimate for 2011 = $12,000 / (0.808/0.919) = $13,649

Process variance = 6.074×10^{11} = σ^2 x Reserves = 25,000 x $24,296,000

Total SDev = σ=1,153,213 = $\sqrt{850{,}000^2 + Process\ Variance}$

CV = 0.0475 = 1,153,213 / 24,296,000

Part b: 0.5 point

Sample Answer 1

The CV will be reduced. This is because we are relying on more information like premium or exposure, and this information allows us to make significantly better estimate of the reserve.

Sample Answer 2

CV should decrease because Cape Code uses more info (exposures) and uses a more stable LR for immature years instead of relying solely on possibly highly leveraged LDFs.

EXAMINERS' REPORT

Part a

- Candidates were expected to know how to estimate parameters and unpaid claims using claims development models related to Chain Ladder and Cape Cod loss reserving methods.
- Candidates generally knew how to set up and calculate the individual pieces required to calculate the coefficient of variation (CV).
- The most common error was keeping the total reserves in thousands and using the other inputs as whole dollars. Additional common errors included using the wrong truncation date, failing to truncate the LDFs, using ultimate losses in place of unpaid claim estimates, and applying the parameter standard deviation in place of parameter variance.

Part b

- Candidates were expected to know key assumptions of the models and how to test them, original Mack chain-ladder assumptions, relationship of variance assumptions to methods of calculating development factors, and how to test whether the methods work and how well the models fit.
- Candidates generally knew that the CV would be reduced by changing from the LDF method to the Cape Cod method. However, many were not able to give the correct explanation for this.
- Common errors included stating that Cape Cod has fewer parameters and therefore would have lower parameter variance and higher process variance. The original paper showed an example in which both the parameter and process variances were reduced (although the process variance was only slightly reduced). Clark did mention that it is possible for the Cape Cod method to have a "somewhat higher process variance". Some candidates wrote that the CV would increase or that the direction was uncertain.
- Other candidates argued that the reserves would be lower/higher for Cape Cod and therefore that would decrease/increase the CV.

QUESTION 3

TOTAL POINT VALUE: 2.25

LEARNING OBJECTIVE: A2: Estimate parameters and unpaid claims using claims development models related to loss reserving methods such as chain ladder, Cape Cod, chain ladder plus calendar-year effects, and Bornhuetter-Ferguson.

SAMPLE ANSWERS

Part a: 1.5 points

Sample Answer 1

Weighted residual = $\dfrac{C_{i,k+1} - C_{i,k} \cdot f_k}{\sqrt{C_{i,k}}}$

f_k = Sum of 24 month cumulative / sum of 12 month cum cumulative = 16200 / 9000 = 1.8

AY	Cik	Ci k+1	fCik	Residual
08	1700	3600	3060	13.097
09	2300	3200	4140	(19.6)
10	1200	1700	2160	(13.279)
11	500	2600	900	76.026
12	2600	3000	4680	(32.95)
13	700	2100	1260	31.75

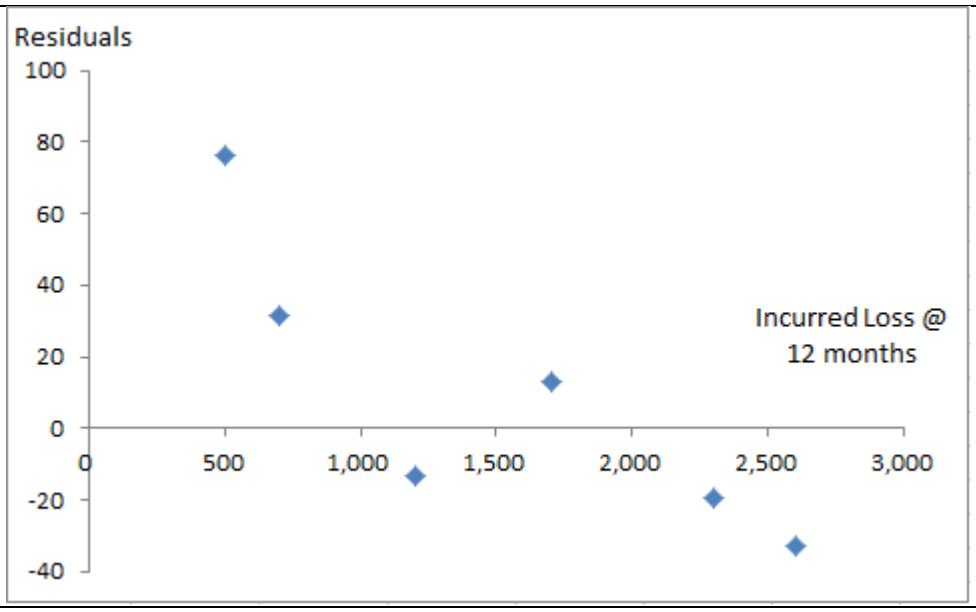
Sample Answer 2

In full dollars				
AY	12	A-24	E-24	R
2008	1,700,000	3,600,000	3,060,000	414.161
2009	2,300,000	3,200,000	4,140,000	-619.818
2010	1,200,000	1,700,000	2,160,000	-419.921
2011	500,000	2,600,000	900,000	2404.163
2012	2,600,000	3,000,000	4,680,000	-1041.892
2013	700,000	2,100,000	1,260,000	1003.992

Sample Answer 3

In millions				
AY	12	A-24	E-24	R
2008	1.7	3.6	3.1	0.414
2009	2.3	3.2	4.1	-0.620
2010	1.2	1.7	2.2	-0.420
2011	0.5	2.6	0.9	2.404
2012	2.6	3.0	4.7	-1.042
2013	0.7	2.1	1.3	1.004

Sample Residual Plot



Part b: 0.75 point

Sample Answer 1

This is testing the assumption that the variance of the next period's losses is proportional to the prior periods reported loss. For the assumption to be met, we expect to see the residuals randomly scattered around 0. This is not the case with this plot as we clearly see a decreasing trend in the residuals as claim size increases The assumption has not been met.

Sample Answer 2

Variance of next year's incurred loss is proportional to incurred loss to date and a factor based on age. Since the points have a decreasing pattern (i.e. not random), the assumption is violated.

EXAMINERS' REPORT

Part a

- Candidates were expected to know how to calculate weighted residuals and weighted loss development factors using Mack's method.
- Candidates generally scored well on this part.
- Common mistakes encountered were inability to recall formulas, simple computational errors, and not appropriately labeling the graph axes.

Part b

- Candidates were expected to know the relation of the variance assumptions to methods of calculating development factors and how to test whether these assumptions have been violated or not.
- The most common mistake was to refer to the expected value rather variance assumption.

QUESTION 4	
TOTAL POINT VALUE: 3.5	**LEARNING OBJECTIVE:** A2: Estimate parameters and unpaid claims using claims development models related to loss reserving methods such as chain ladder, Cape Cod, chain ladder plus calendar-year effects, and Bornhuetter-Ferguson

SAMPLE ANSWERS

Part a: 3 points

Sample Answer 1

AY	12-24 Months	24-36 Months	36-48 Months	48-60 Months	60-72 Months	72-84 Months
08	**L**	*****	**L**	*****	**L**	*****
09	**S**	**L**	**S**	**L**	**S**	
10	**S**	**S**	**L**	**S**		
11	**S**	**L**	**S**			
12	**L**	**S**				
13	**L**					
Median	**6.50**	**2.55**	**1.55**	**1.30**	**1.15**	**1.05**

S indicates less than median for development age

L indicates greater than median for development age

* indicates equal to median for development age

Aj = diagonal j

Sj = # of S in diagonal J; Lj = # of L in diagonal J

Nj = Sj + Lj

Mj = (n-1)/2; round down

Zj = Min (Sj,Lj)

Ignore j=1 since only one element

j	S	L	n	m	Z	E[Zn]	Var[Zn]
2	1	0	0	0	0	0	0
3	1	2	3	1	1	0.750	0.188
4	3	0	3	1	0	0.750	0.188
5	0	5	5	2	0	1.563	0.371
6	4	1	5	2	1	1.563	0.371
Total					Z = 2	4.625	1.117

n=1 E(z)= 0 Var(z)=0

n=3

z	Comb	Prob
0	2	2/(2+6)=0.25
1	3*2=6	6/(2+6)=0.75

E(z)=0.25(0)+0.75*(1)=0.75
$E(z^2)=0.25(0)^2+0.75*(1)^2=0.75$
$Var(z)=0.75 – 0.75^2=0.1875$

n=5

Z	Comb	Prob
0	2	2/32
1	5*2=10	10/32
2	20	20/32

E(z)=2/32(0)+10/32(1)+20/32(2)=1.5625
$E(z^2)=2/32(0)^2+10/32(1)^2+20/32(2)^2=2.8125$
$Var(z)=2.8128 – (1.5625)^2=0.371$

Z=Sum(Zj)=2
E(Z)=Sum(E(Zj))=4.625
Var(Z)=1.117
95% CI 4.625+/-1.96*Sqrt(1.117)
(2.554, 6.696)
Z=2 is not inside CI. So reject H0 that there are no CY effects.

Sample Answer 2

08	**L**	*	**L**	*	**L**	*
09	**S**	**L**	**S**	**L**	**S**	
10	**S**	**S**	**L**	**S**		
11	**S**	**L**	**S**			
12	**L**	**S**				
13	**L**					

For j=2, S=1, L=0, Z=min(S,L)=0, n=S+L=1, M=[(n-1)/2]=0, E(Z)=1/2-Comb(1-1,0)*1/2=0
Va(Z)r=1/2*(1-1)-Comb(1-1,0)*1/2*(1-1)+0-0^2=0

For j=3, S=1, L=2, Z=1, n=3, M=1, E(Z)=3/2-Comb(3-1,0)*3/2^3=.75
Var(Z)=3/2*(3-1)/2-Comb(3-1,1)*3/2^3*(3-1)+.75-.75^2=.1875

For j=4, S=3, L=0, Z=0, n=3, M=1, E(Z) =.75, Var(Z)=.1875

For j=5, S=0, L=5, Z=0, n=5, M=2, E(Z)=5/2-Comb(5-1,2)*5/2^5=1.5625
Var(Z)=5/2*(5-1)/2-Comb(5-1,2)*5/2^5*(5-1)+1.5625-.1.5625^2=0.371

For j=6, S=4, L=1, Z=1, n=5, M=2, E(Z) =1.5625, Var(Z)=.371

Z=0+1+0+0+1=2
E(Z)=0+0.75+0.75+1.5625+1.5625=4.625
Var(Z)=0+0.1875+0.1875+0.371+0.371=1.117
4.625-1.96*1.117^.5=2.554

Z=2<2.554
Reject the null hypothesis – The triangle displays significant calendar year effect

Part b: 0.5 point

Sample Answer 1

- Claims department process change could cause a strengthening of reserves for all AYs leading to an unusually strong diagonal
- A court ruling with impact on claims that already occurred could cause all AY's to shift during a calendar year

Sample Answer 2

- A change in claims handling system can affect calendar year claims development
- A legislative change affecting benefit levels can also affect CY claims because it applies to claims from all AYs

Other responses that made mention of any of the following were accepted as one of the two responses required:

- High inflation
- Changing inflation
- Changes in payment processes

EXAMINERS' REPORT

The topic tested is clearly identified on the syllabus and the exam problem was very similar to the example in the Mack paper. In general, candidates did well on this question; about a third of the candidates earned full credit.

Part a

- Most candidates did not show the calculations for the median LDFs for each evaluation. However, no deduction was made if the 'rank' picture was correct.
- A number of candidates solved the problem using Spearman's T Method. However, this did not receive credit because the method is a development year test while the problem was looking at calendar year effects.

Part b

A common response was the single word 'inflation'. This did not receive credit because it is changes in inflation that cause calendar year effects. However, 'high inflation' was accepted because it implied that inflation was increasing.

QUESTION 5

TOTAL POINT VALUE: 2.5

LEARNING OBJECTIVE: A2: Estimate parameters and unpaid claims using claims development models related to loss reserving methods such as chain ladder, Cape Cod, chain ladder plus calendar-year effects, and Bornhuetter-Ferguson

SAMPLE ANSWERS

Sample Answer 1

AY	X	Y	(X - E[X])	(Y - E[Y])	$(X - E[X])^2$	$(Y - E[Y])^2$	(X - E[X]) * (Y - E[Y])
2009	1.5000	0.4500	0.3475	0.1025	0.1208	0.0105	0.0356
2010	0.8000	0.3800	(0.3525)	0.0325	0.1243	0.0011	(0.0115)
2011	1.1300	0.2000	(0.0225)	(0.1475)	0.0005	0.0218	0.0033
2012	1.1800	0.3600	0.0275	0.0125	0.0008	0.0002	0.0003
Mean	1.1525	0.3475		Σ	0.2463	0.0335	0.0278

$$r = \frac{\Sigma(X - E[X]) * (Y - E[Y])}{(\Sigma(X - E[X])^2 * \Sigma(Y - E[Y])^2)^{.5}} = \frac{0.0278}{(0.2463 * 0.0335)^{.5}} = 0.3065$$

n = 4

$T = r * [(n - 2) / (1 - r^2)]^{.5} = 0.3065 * [(4 - 2) / (1 - .3065^2)]^{.5} = 0.4553$

t-statistic = 1.8860

Since 0.4553 < 1.8860, the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent is met

Sample Answer 2

AY	X	Y	XY		$(X - E[X])^2$	$(Y - E[Y])^2$
2009	1.5000	0.4500	0.6750		0.1208	0.0105
2010	0.8000	0.3800	0.3040		0.1243	0.0011
2011	1.1300	0.2000	0.2260		0.0005	0.0218
2012	1.1800	0.3600	0.4248		0.0008	0.0002
Mean	1.1525	0.3475	0.4075	Σ	0.2463	0.0335
				n	4	4
				σ^2	0.0616	0.0084
				σ	0.2481	0.0915

$$r = \frac{E[XY] - E[X] * E[Y]}{\sigma_X * \sigma_Y}$$

$$r = \frac{0.4075 - 1.1525 * .3475}{(0.2481 * 0.0915)} \qquad r = .3065$$

n = 4

$T = r * [(n - 2) / (1 - r^2)]^{.5} = 0.3065 * [(4 - 2) / (1 - .3065^2)]^{.5} = .4553$

t-statistic=1.8860

Since 0.4553 < 1.8860, the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent is met.

Sample Answer 3

AY	X	Y	XY	X^2	Y^2
2009	1.5000	0.4500	0.6750	2.2500	0.2025
2010	0.8000	0.3800	0.3040	0.6400	0.1444
2011	1.1300	0.2000	0.2260	1.2769	0.0400
2012	1.1800	0.3600	0.4248	1.3924	0.1296
Mean	1.1525	0.3475	0.4075	1.3898	0.1291
$Mean^2$	1.3283	0.1208			

$$r = \frac{E[XY] - E[X] * E[Y]}{((E[X^2] - E[X]^2) * (E[Y^2] - E[Y]^2))^{.5}}$$

$$r = \frac{0.4075 - 1.1525 * .3475}{((1.3898 - 1.3283) * (0.1291 - 0.1208))^{.5}}$$

r = 0.3065
n = 4
$T = r * [(n - 2) / (1 - r^2)]^{.5}$
$T = 0.3065 * [(4 - 2) / (1 - .3065^2)]^{.5}$
T = 0.4553
t-stat = 1.8860
Since 0.4553 < 1.8860, the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent is met.

Sample Answer 4 (accepted response using elements of Mack paper)

AY	X	Y	Rank X	Rank Y	Rank $(X-Y)^2$
2009	2.5000	1.4500	4	4	-
2010	1.8000	1.3800	1	3	4
2011	2.1300	1.2000	2	1	1
2012	2.1800	1.3600	3	2	1
			S =	Σ	6

$$r = 1 - \frac{S}{n(n^2 - 1)/6}$$

$$r = 1 - \frac{6}{4 * (4^2 - 1)/6}$$

r = 0.400
n = 4
$T = r * [(n - 2) / (1 - r^2)]^{.5}$
$T = 0.400 * [(4 - 2) / (1 - .400^2)]^{.5}$
T = 0.6172

t-statistic = 1.8860
Since 0.6172 < 1.8860, the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent is met.

Sample Answer 5 (accepted response using elements of Mack paper)

AY	X	Y	Rank X	Rank Y	Rank $(X-Y)^2$
2009	2.5000	1.4500	4	4	-
2010	1.8000	1.3800	1	3	4
2011	2.1300	1.2000	2	1	1
2012	2.1800	1.3600	3	2	1
			S =	Σ	6

$$r = 1 - \frac{S}{n(n^2 - 1)/6}$$

$$r = 1 - \frac{6}{4 * (4^2 - 1)/6}$$

r = 0.400
n = 4
$T = r * [(n - 2) / (1 - r^2)]^{.5}$
$T = 0.400 * [(4 - 2) / (1 - .400^2)]^{.5}$
T = 0.6172

Var [T] = 1 (# of AY's - 2) x (# of AY's -3) / 2
# of AY's : 6
Var [T] = 0.167
Std Dev [T] = 0.408
t-statistic = 1.8860

Range (+/-) 0.7700 = 0.408 * 1.886
Range (-0.770, 0.770)

Since 0.6172 is within the range the null hypothesis that the 12-24 month and 24-36 month age-to-age factors are independent is met.

EXAMINERS' REPORT

Overall, many candidates performed very well on this question. Candidates needed to know key assumptions of the chain ladder models and how to test these assumptions. The core of the question is determining whether the age-to-age factors are independent.

The question referenced Mack's correlation test by mistake; the intended approach was to use Venter's correlation test. Due to this error, we accepted a variety of responses which used some elements of Mack's correlation test. See Sample Answers 4 and 5 for examples of responses receiving full credit even though they were not the intended responses to the question.

QUESTION 6

TOTAL POINT VALUE: 2.75

LEARNING OBJECTIVE: A4: Estimate unpaid claims for various layers of claims.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

Ult limited @ 250,000 = 44,622M x 0.6 x (1 – 0.47) = 14, 189,796
Ult limited @ 1M = 44,622M x 0.6 x (1 – 0.05) = 25,434,540
Ult. layer 250000 to 1,000,000 = 25,434,540 – 14,189,796 = 11,244,744

Sample Answer 2

LR approach
ultimate at 1,000,000 limit = (44,622,000)(.6)(.95)=25,434,540
Ultimate at 250,000 limit = (44,622,000)(.6)(.53)=14,189,796
Difference = 25,434,540 – 14,189,796 = $11,244,744

Part b: 1.25 points

Sample Answer 1

	12-24	24-36	36-48
LDF at 250k	1.481	1.382	1.105
To Ultimate	2.262		

Ultimate at 250k = 6,216 x 2.262 = 14,061k

	12-24	24-36	36-48
LDF at 1M	1.828	1.673	1.212
To Ultimate	3.707		

Ultimate at 1M = 6,984 x 3.707 = 25,890k
Ultimate in layer = (25,890 – 14,061) x 1,000 = 11,829,000

Sample Answer 2

At 250k limit:
LDF(1) = (8,472+ 8,748 + 9,598) / (6,000 + 5,620 + 6,482) = 1.4815
LDF(2) = (11,642 + 12,156) / (8,472 + 8,748) = 1.382
LDF(3) = 12,860 / 11,642 = 1.1046
Ultimate AY loss @ 250k = 6,216 x 1.4815 x 1.382 x 1.1046 = 14,058

At 1M limit:
LDF(1) = (12,041 + 10,541 + 13,877) / (6,798 + 5,823 + 7,321) = 1.828
LDF(2) = (19,888 + 17,896) / (12,041 + 10,541) = 1.673
LDF(3) = 24,106 / 19,888 = 1.212
Ultimate AY loss @1M = 6,984 x 1.828 x 1.673 x 1.212 = 25,887

Implied Ultimate AY 2014 loss between 250-1M = 25,887 – 14,058 = 11,829 (000s)

Part c: 1 point

Sample Answer 1

XSLDF = $LDF^{unlim} \times (1 - R^{L}) / (1 - R^{L}_{12})$
Ultimate $R^{L} = 1.21 / 2.27 = 0.533$
$R^{L}_{12} = y = 0.533 \times e^{0.177 \times 3} = 0.906$

XSLDF = 3.707 x (1 – 0.533) / (1 – 0.906) = 18.417
Ult XS Losses = 18.417 x (6,984 – 6,216) x 1,000 = 14,144,256

Sample Answer 2

Ult Ratio = 1.21 / 2.27 = 0.533 = ILF^{250K} / ILF^{1M}
Y for AY2014 = 0.533 x $e^{0.177\,(3)}$ = 0.906 = R^L_t
LDF = R^L_t (LDF^L) + (1 – R^L_t) $XSLDF^L$
3.707 = (0.906) (2.261) + (1 – 0.906) $XSLDF^L$
$XSLDF^L$ = 17.644
Ult = (6,984,000 – 6,216,000) (17.644) = $13,550,592

Sample Answer 3

$XSLDF^L_t$ = LDF_t x (1 – R^L) / (1 – R^L_t)
Ult ratio = R^L_t = (1 – 0.47) / (1 – 0.5) = 0.558
At t=12 months, y = Ult ratio $e^{0.177 \times 3}$ = 1.70 x Ult ratio = 1.70 x 0.558 = 0.948
$XSLDF^L_t$ = 3.707 x (1 – 0.558) / (1 – 0.948) = 18.417
Current losses in layer = 6,984,000 – 6,216,000 = 768,000
Ult losses in layer = 768,000 x 31.77 = 24,399,360

Sample Answer 4

U = 12,860 / 24,106 = 0.533
XSATU = ATU x (1 – R^L_{48}) / (1 – R^L_{12}) = 3.708 x (1 - U e^0) /(1 - U $e^{0.177 \times 3}$) = 18.508
XS Ult = (6,984K – 6,216K) x 18.508 = 14,213K

Sample Answer 5

Ult ratio = (6,984K x 3.7079) / (6,216K x 2.2616) = 0.5429
$Ratio^{250/1000 @ 12 months}$ = Ult ratio x $e^{0.177t}$ = 0.5429 x $e^{0.177 \times 3}$ = 0.92337
LDF = 3.7079 x (1 – R_{ULT}) / (1 – R_{12}) = 3.7079 x (1 – 0.5429) / (1 – 0.9233) = 22.0975
(6,984,000 – 6,216,000) x 22.0975 = 16,970,880

Sample Answer 6

Ult ratio x $e^{0.177 \times 3}$ = 6,216 / 6,984
Ult ratio = 0.523
$LEV_{250-1000}/LEV_{1000}$ at 12 months = 768 / 6,984
$LEV_{250-1000}/LEV_{1000}$ at ult = 1 – 0.523
CDF = 3.698 x (1 – 0.523) / (768 / 6,984) = 16
16 x (6,984 – 6,216) = 12,288

EXAMINERS' REPORT

Part a

Candidates performed very well on this part in general, with a majority receiving full credit. This part related to knowledge statements about methods for estimating unpaid claims in a layer excess of a retention but bounded by a limit, and how to apply per-occurrence charges in particular. The three key steps were to determine expected losses at $250k limit, to determine expected losses at $1M limit, and to take the difference to obtain expected losses in the $750k excess of $250k layer.

A few candidates attempted to use ILFs instead of per-occurrence charges to calculate losses by layer, which doesn't work as the highest ILF for losses above $1M is not provided in the problem. Other candidates included an extraneous (1.0 - 0.47) multiplied against the 0.05 per-occurrence charge at

$1M, even though the per-occurrence charges apply strictly to ground-up losses. Finally, a few candidates attempted to include an aggregate loss charge in the calculations, even though no aggregate loss coverage was indicated in the problem.

Part b

Candidates performed very well on this part in general, with a majority receiving full credit. This part related to knowledge statements about methods for estimating unpaid claims in a layer excess of a retention but bounded by a limit, and how to estimate and apply loss development factors for losses in different loss layers. The key steps were to determine cumulative LDFs at a $250k loss limit, determine cumulative LDFs at a $1M loss limit, multiply those cumulative LDFs by reported losses for AY 2014 at a 12 month evaluation, and take the difference between those calculated ultimate layer losses to project the ultimate losses in the $750k excess of $250k loss layer.

A few candidates mistakenly used ILFs in the formulas instead of calculating LDFs from the loss development triangles provided, or else they mistakenly applied both LDFs and ILFs. A few other candidates subtracted 1.0 from each of the cumulative LDFs when applying the LDFs to the reported losses at either or both of the $250k and $1M limits, which corresponded to the candidate providing IBNR for the excess layer rather than the requested ultimate losses. In other cases, there were mathematical errors made in the computation and application of the interval LDFs, but given that LDFs needed to be computed for six different interval/limit combinations, those mathematical errors were fairly infrequent.

Part c

This tested the relationship of development patterns between layers.

In order to obtain full credit, candidates needed to figure out how losses limited at 250K and 1000K relate to each other, both at 12 months of development and at ultimate.
As a second step, they needed to find the loss development factor from 12 months to ultimate for the losses within that layer and finally, apply that LDF to the reported losses at 12 months.

This question was challenging and a significant number of candidates were unable to provide a meaningful response.

Another portion of candidates were not able to provide a good calculation for the first two steps, but they provided a calculation of ultimate losses in the layer using the correct amount or reported losses in the layer (given in the question) with whatever LDF they came up with, earning partial credit.

Other candidates were able to fully answer the question, but made an error in deriving the ratio of reported losses limited at 250K to reported losses limited at 1M at various development periods. The variable t in the formula is defined as being the time to ultimate and, while the proper exponent in the formula for t at 12 months development is 4 – 1 = 3, several candidates used t=1.

Candidates used several different approaches to solve the problem:

- Figuring out the ratio of losses at ultimate can be calculated using Excess charges, ILF, actual reported losses from AY 2011 or from ultimate losses calculated in part (b).
- Figuring out the ratio of losses at 12 months can be calculated using the formula given in the question but also directly from the reported losses at 12 months.
- Finally, there are 2 possible equations that can be used to calculate the LDF to ultimate for the losses in the layer.

All these possible variances lead to several combinations of acceptable methods, with final answers varying within a range from $12 million to $24 million.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

QUESTION 7	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** A5: Describe the various sources of risk and uncertainty that are associated with the determination of reserves. Calculate risk margins that consider these sources of risk and uncertainty.

SAMPLE ANSWERS

Sample Answer 1

1) Are we selling a wide range of policy limits?
   Asking this because different limited losses develop very differently and may want to group them into groups.
2) Are we writing a lot in CAT prone areas?
   Asking this because CAT vs nonCAT losses develop differently and may want to separate if have a lot of cat exposures.
3) Is there any expectation of legislative changes in some major states?
   This may have an impact on the auto liab. outstanding claims, e.g. if a court has been more pro-plaintiff, etc.

Sample Answer 2

1) Has there been any catastrophe event in any geographic location?
   This question is important because cats have a different dev pattern than other "normal" losses, so we should model catas losses separated of the rest.
2) Are the coverages the same in all geographic regions?
   This question is important because if the coverage is different in between regions, the dev. patterns are likely to be different so the actuary should model only the policies with the same coverage altogether.
3) Are there any regions where the claims handlers are very understaffed or overstaffed?
   If there are difference between the number of claim handlers and the number of claims in different geographic areas, then the time to settle claims will be different and should be modeled for separately (or adjusted)

Sample Answer 3

1) What are the coverages written under each line?
   Since different coverages have different development patterns, it is essential to group by coverage under each line.
2) What are the limits or deductibles used in underwriting?
   Since different limits/deductibles of policies have different development patterns. E.g. large limit may have a higher development later on.
3) Are there differences in regulation or other characteristics for the geographic locations?
   Since each location may have specific regulations, legislation, economic/social environment, the claim development patterns may be different.

Sample Answer 4

1) Is homeowners exposed to catastrophe (event) risk? What/where are the events/locations

of concern?
Ask this question b/c we should separate catastrophes and non catastrophic claims for homeowners line due to different development patterns.

2) Are there different claims practices in different geographic regions?
If the company has 2 claims divisions, East and West, each w/ its own management, we should segment East vs. West auto and home claims b/c each region will have unique development patterns.
3) Are the coverages for personal auto unique, e.g. is there liability coverage and PD coverage? Are these handled by different departments?
Liability claims have a longer tail so it is appropriate to put these claims in their own class due to different development pattern than PD.

EXAMINERS' REPORT

The candidate was expected to know appropriate considerations for determining how to segment a portfolio for reserving analysis.

Common reasons for not receiving full credit included:

- Questions about data patterns – these would not be questions to ask of management but rather determined from looking at the data.
- Good questions, but weakly reasoned logic – it is not sufficient to simply say to group losses; need to know why it is important (e.g., different groups may have different development patterns).
- Questions about volume for credibility purposes – should be able to get that from data, not management.
- Questions only asking about deductibles, since for auto and homeowners the deductibles are relatively small and wouldn't materially impact development for segmentation.
- Questions about correlation between lines – more a consideration for risk margins rather than segmentation.

QUESTION 8	
TOTAL POINT VALUE: 3.5	**LEARNING OBJECTIVE:** A5: Describe the various sources of risk and uncertainty that are associated with the determination of reserves. Calculate risk margins that consider these sources of risk and uncertainty.

SAMPLE ANSWERS (BY PART, AS APPLICABLE)

Part a: 1.5 points

Sample Answer 1

Specification Error – the risk that underlying process is too complex to selet a model that fully explained the insurance process. Umbrella claims are inherently more variable due to their high attachment and longer tail.

Parameter Selection Error – the risk that the model is unable to measure accurately the predictors in claim cost or trends in those predictors. Certain trends, like severity trend, have larger impacts on excess layers – for umbrella this will create more importance of getting those factors right.

Sample Answer 2

Specification Error – risk associated with the fact you can't develop a perfect model for insurance because it is too complex. Umbrella is a much less homogeneous line than PA and CA and also a low frequency high severity line so we anticipate higher volatility and therefore higher CoV

Data Error – risk associated with errors in the data, or lack of understanding of the data, or unreliable data. Umbrella is a much more nuanced lined than PA or CA, with fewer industry statistics, so fewer benchmarks and in general there is less industry expertise, so the chances for data to be unavailable or for expertise of understanding the data to be low is much greater.

Part b: 0.75 point

Sample Answers

- Catastrophe risk would affect both personal and commercial auto because a catastrophe would affect an entire area and if both personal and commercial auto are in that area then you will see large losses in both lines.
- Economic risk such as inflation, fuel prices – personal auto and commercial auto are both subject to the same inflation in terms of the replacement cost of vehicles & vehicle parts. If costs of the replacement parts increased in one line, it will increase in the other as well.
- Recovery risk is highly correlated between PA & CA because it is risk associated from recoveries, like from damaged cars.
- Claims management changes b/w PA & CA b/c both would fall under the same chief claims officer & changes in claims handling would likely affect both.
- Regulation/Political Risk. Both personal and commercial auto will be subject to the same legal shifts and regulatory requirements. Because both offer the same general types of coverages, changes to minimum BI policy limits (For example) will impact both lines.

Part c: 0.75 point

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

Sample Answers

- Claim Management Process Risk – Changes in settlement, reporting, finalization of claims. PA and CU unlikely to be handled by the same claims department.
- Legal (Political/Legislative Risk) – personal auto is much more regulated than commercial auto so it is unlikely that any regulatory or legal changes would impact both.
- Political and legal risk between personal auto and commercial umbrella is likely lower because most political attention regarding legal insurance required, rating, etc. is in regards to personal insurance. There is not as much regulation of umbrella coverage.
- Latent claim can have a low correlation between personal auto and umbrella as personal auto is short tail and is not likely that a latent claim, say asbestos, can affect personal auto and commercial umbrella at the same time as their cause of loss will be very different.
- Event risk: personal auto and commercial umbrella are unlikely to be impacted by any one event. For example, an event would cause damage to PA but not CU as CU is just liability.
- Recovery risk – recovery from PA are mainly subro and salvage from other insurers. Recovery from CU are mainly by reinsurance. Therefore, the recovery risk of PA has low correlation with that of CU.
- Personal auto & commercial auto would have low correlation for expense risk. The two have different claims units – one entry-level and systemized, the other highly skilled and expensive. Further, umbrella would use attorney's more frequently and claims would volatility would lead to expense volatility personal wouldn't have.
- Claims management process between personal auto and commercial auto are low because the insurers likely to have separate claims staff handle comm and personal claims. Change in one is unlikely to be implemented in the other – different practices.

Part d: 0.5 point

Sample Answer 1

= SQRT [(.60 * 5%)^2 + (.35 * 5%)^2 + (.05 * 7%)^2]

= .035

Sample Answer 2

$=\sqrt{(.60 * .05)^2 (.35 * .05)^2 (.05 * .07)^2}$

=0.0349

EXAMINERS' REPORT

Overall, candidates performed well on this question. Detailed commentary provided by part below.

Part a

Candidates were expected to be able to describe two of the main sources of internal systemic risk, along with a possible reason for a higher umbrella CoV for each of the two sources.

On the first part (describing sources of internal systemic risk), candidates could earn full credit either for identifying the risk and providing a brief description, or for giving a more robust description, in which case an identification was not necessary. For the identification, candidates were given credit for writing either "model" or "specification" error.

For data error (an internal systemic risk source), defining data error as solely the risk of having little data, without any further explanation, did not earn credit.

For explaining the higher umbrella CoV, several reasons were acceptable. Generally anything that demonstrated an understanding of the complexity/nature of the umbrella line was given credit.

While candidates generally did well, some common errors include candidates identifying, but not briefly describing the two sources of internal systemic risk and in general, insufficient explanations.

Part b

Candidates were asked to give a source of external systemic risk and correctly identify two lines that have high correlation. They were also expected to explain why the two lines have high correlation for the risk given.

For the explanation portion of this question, several reasons were acceptable. Demonstrating an understanding of why two lines would have high correlation earned credit.

The vast majority of candidates received full credit for this part.

The most common error was to give a flawed or insufficient explanation for why the two lines were correlated.

Part c

Candidates were expected to give a source of external systemic risk and correctly identify two lines that have low correlation. They were also expected to give a proper explanation of why the two lines have low correlation for the risk given.

For the explanation portion of this question, several reasons were acceptable. Demonstrating an understanding of why two lines would have low correlation was given credit.

Generally candidates did well, but some struggled to give a good explanation.

One common error was to give a flawed explanation of why two lines saw low correlation. Another common error was for the candidate to identify two lines that should properly be high correlation for the risk given combined with an example of an uncorrelated event for the two lines that ignores a more global perspective of correlations. A prevalent example of this error was to provide one economic scenario that might not affect both lines while ignoring the fact that all lines are affected by inflation. A variant of this example was to confuse difference in magnitude with the impact for low correlation.

Part d

Candidates were expected to calculate the independent CoV of the three lines of business, assuming independence.

Generally candidates did well on this question. Common errors included not applying the weights for each line of business, using the wrong set of CoVs, and minor calculation errors.

QUESTION 9	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** A5: Describe the various sources of risk and uncertainty that are associated with the determination of reserves.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answer 1

Since Portfolio B has a very long claim run-off time, the Premium Liability COV should be higher than the OCL COV. Moreover, Portfolio B is larger (in size) than Portfolio A, which is also having the same length of claim runoff years. Thus the OCL COV for A is larger than the OCL COV for B.

5.5% > x, 7.0% > x

In addition, OCL COV for B is longer than OCL COV for C, since they are the same size, and C has a much shorter runoff time than B → x > 0.5%

Select x = 5%

Sample Answer 2

5.5% - since the tail of claims matches A (C is a lot quicker, so lower CV), it would be an appropriate CV to account for the uncertainty.

Part b: 0.75 point

Sample Answer 1

PL COV(A) > PL COV(B) (since A is smaller than B, but with the same runoff period)
PL COV(A) > OCL COV(A) (more uncertainty for PL in long tail lines)
Y > 7% → select y = 7.5%

Sample Answer 2

A has smaller size & longer runoff length than C → that y should definitely be higher than 0.3%. Smaller book + same runoff length than B → y should be higher than 7%
I choose y to be 10% because it is longer tailed & smaller sized

Sample Answer 3

Y = 7.0% because this matches portfolio B which has a similar claim runoff length. Premium liability is risk that premiums written will not cover losses, and these two appear to write similar length (likely liability) coverage

EXAMINERS' REPORT

- Candidates generally performed well with on this question, with a majority of candidates receiving full credit. Candidates were expected to understand the relationships between length of claim runoff and portfolio size and how that affects variability.
- Although candidates were successful overall, candidates earned full credit on part a more frequently than on part b. Some candidates struggled with how premium liability COVs are affected by length of claim runoff and portfolio size more than they did with the outstanding claim liability COV. Some candidates explained how the mean of the OCL or the PL were impacted rather than the COV of the OCL or PL. Other candidates thought that

a lower portfolio size meant there was less premium liability variability as opposed to more variability.

Part a

- Candidates performed well on part a, with a majority of candidates receiving full credit.
- The candidate was expected to understand how the COV for OCL is impacted by length of claim runoff and portfolio size.
- In order to receive full credit, the candidate was expected to provide an acceptable value for *x* and explain why it is acceptable in relation to internal benchmarks, and why we would expect *x* to differ from the benchmarks.
- The most common mistake was selecting a value for x greater than 5.5% – some candidates mistakenly thought a larger portfolio size increases the coefficient of variation – the mean of the OCL is expected to increase, but we would expect the variability as a percentage of the mean to actually go down as the volatility due to random effects decreases.
- Some candidates explained how the COV should relate to the benchmarks but failed to actually provide a value.
- Other candidates provided correct values but didn't explain why they were reasonable in the context of the internal benchmarks.

Part b

- Candidates performed well on part b, with a majority of candidates receiving full credit.
- Candidates were expected to understand how the COV for PL is impacted by length of claim runoff and portfolio size.
- In order to receive full credit, candidates were expected to provide an acceptable value for *y* and explain why it is acceptable in the context of internal benchmarks, and why we would expect *y* to differ from the benchmarks.
- The most common mistake was selecting a value for y less than 7% – some candidates mistakenly thought a larger portfolio size increases the coefficient of variation – the mean of the PL is expected to increase, but we would expect the variability as a percentage of the mean to actually go down as the volatility due to random effects decreases.
- Some candidates mistakenly thought that for long-tailed lines, COV(OCL) > COV(PL). They had this relationship reversed, we would actually expect COV(PL) to be greater than COV(OCL) for long-tailed lines.
- Some candidates explained how the COV should relate to the benchmarks but failed to actually provide a value.
- Other candidates provided reasonable values but did not explain why these were reasonable in the context of the internal benchmarks.

QUESTION 10	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE:** A7: Describe operational risk and demonstrate possible mitigation and quantification methodology.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

- No heteroscedasticity is present in the AY graph as the results appear random around 0
- Heteroscedasticity is present in the DP graph as there is a clear upward trend in the residuals starting with development period 5

Sample Answer 2

- No heteroscedasticity is present in the AY graph as the residuals appear to have constant variance
- Heteroscedasticity is present in the DP graph as the variance of the residuals by development period is different

Sample Answer 3

- No heteroscedasticity is present as the residuals appear to be random around 0, however, it's possible that it may exist with the more recent accident years and we simply don't know due to a low number of data points
- Heteroscedasticity is present in the DP graph as the residuals in the later development periods are all above 0, which is not the case for the earlier development periods.

Part b: 0.5 point

Sample Answer 1

Bootstrapping assumes residuals are independent and identically distributed. Heteroscedasticity violates this assumption as the residuals do not have constant variance.

Sample Answer 2

Bootstrap model samples residuals from all observed residuals to create new triangle from which to calculate LDFs. If residuals distributed differently in different accident years or development periods, it is not appropriate to sample from all residuals (assumption of i.i.d. residuals violated)

Part c: 1 point

Sample Answer 1

- Stratified Sampling – Group residuals with like variances. Only sample residuals from these groups.
- Hetero-Adjustment Factor – Group residuals with like variances. Calculate the standard deviation of each group. Adjust residuals with smaller variances upward by the ratio of the largest variance group to the group's variance. This allows us to sample from the entire triangle. After sampling, undo the adjustment to reflect the true relationship of the data.

Sample Answer 2

- Stratified Sampling – Group residuals together based on the size of their variance. For each part of the Triangles, sample only from the corresponding group of residuals where

the sampled residuals and proceed with rest of the procedure.

- Hetero Adjustment – Group residuals based on size of variance for each group determine its standard deviation divide standard deviation by standard deviation of largest group. Multiply all residuals in group by that factor, then we can sample residuals, divide by factors before using to calculate pseudo triangles.

Other Acceptable Answer for the Hetero-Adjustment Factor procedure

- Adjustment: Adjust residuals by multiplying residuals of homogeneous groups by a constant factor [max standard deviation / standard deviation of the group] to give residuals homogeneous variance. Then, divide by the factor once residuals have been sampled.
- Make a heteroscedasticity adjustment to all the data to bring all the variances in line with each other. Run the bootstrapping process with the adjusted data then undo the adjustment to return the results to their original level once the process is complete.

EXAMINERS' REPORT

Candidates performed well on this question overall but part c was challenging. Candidates were expected to know what heteroscedasticity meant and how it applied to the graph shown. Candidates were also expected to know at a high level the adjustments that can be applied to correct for heteroscedasticity.

Part a

Candidates performed extremely well on this part. A few common mistakes were mixing up hetero- and homoscedasticity, and not including any justification for the presence/absence thereof.

Part b

Candidates did fairly well here. Most candidates identified the assumption of the bootstrap model that residuals are i.i.d., but a fair number of candidates did not sufficiently demonstrate how heteroscedasticity violates this assumption. Many candidates who received full credit didn't sufficiently define heteroscedasticity explicitly in this part, but had enough detail from part a to compensate for an otherwise insufficient answer here.

Part c

Candidates did well identifying and explaining the main points of stratified sampling; however, a common error was not giving enough detail regarding the hetero-adjustment factor approach. This is understandable, given that this method simply has more detail to it than stratified sampling. It is worth noting that candidates did not need to give any formulas to receive full credit if their answer contained all the high level aspects of the approach.

QUESTION 11	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** A7: Derive predictive distributions using bootstrapping and simulation techniques. A8: Identify data issues and related model adjustments for reserving models. A9: Test assumptions underlying reserve models.

SAMPLE ANSWERS

Part a: 0.25 point

Sample Answer 1

Incremental values in Age 4 is negative

Sample Answer 2

Sum of incremental values in Age 4 is negative

Part b: 0.5 point

Sample Answers from Multiple Candidates

Year 4, Ages 2 & 3 have values that seems to be outliers
There appears to be a large increase in exposures from Year 1 to Year 2
Year 1 is likely the first year so the data is very thin
Year 1 has a different exposure level
There seems to be missing data (i.e. zeros) for Year 1, starting Age 3
The triangle seems to be incomplete due to the missing data (i.e. zeros) in Year 1

Part c: 0.75 point

Sample Answers for Negative Incremental Values

Add 50 to each of the values in the triangle, solve the GLM and subtract 50 from the modeled result; OR
Add 20 to each of the values in the triangle, solve the GLM and subtract 20 from the modeled result; OR
Add a positive number to each of the values to eliminate the negative values in the triangle, solve the GLM and subtract the positive number from the modeled result; OR
Subtract a negative number to each of the values to eliminate the negative values in the triangle, solve the GLM and add the negative number from the modeled result

Sample Answers for Outliers in Year 4, Ages 2 & 3

Could treat it as missing and estimate it from surrounding values
Exclude Year 4 from the age-to-age factors (Age 1-2 and/or Age 2-3) and/or residual calculations
Exclude outliers from the triangle

Sample Answer for Increased Exposure from Year 1 to Year 2

If earned exposure data is available, divide the whole loss triangle by exposures, using pure premium development (or loss ratio development) instead of total loss development

Sample Answer for Thin/Missing data in Year 1

The entire row (for Year 1) can be removed from the loss triangle
EXAMINERS' REPORT
Candidates were expected to identify the issues which would cause model failure and impact modeling results, as well as how to address the identified issues prior to modeling. In general the candidates scored well. Most of the lost credit was from part c.
Part a
Candidates were expected to identify the negative incremental values in the triangle, which the majority did. The most common error was to identify the zeros in the triangle.
Part b
Candidates were expected to identify two additional issues that may impact modeling results (although they would not cause model failure). These were the outlier in Year 4, Age 2 and the data inconsistency between Year 1 and other years, perhaps due to a change in exposure or missing data. Most candidates could identify at least one of the issues. Common errors included misinterpreting the zeros in Age 5 as missing data (rather than claim closure) and identifying the negative incremental value in Age 4 (as it should have been identified in part a instead).
Part c
Candidates were expected to suggest adjustments to the data to improve modeling results, to address the three issues identified in parts a and b. See the sample answers above for acceptable suggestions. Most candidates provided full-credit solutions for how to adjust the data for outliers (Year 4) and missing/thin data (Year 1). The most common error was related to the negative incremental values issue; candidates described adding a value to each entry of the triangle before modeling, but they failed to mention subtracting the value back out from the modeled results. This response was considered incomplete because model output produced this way would be biased.

QUESTION 12	
TOTAL POINT VALUE: 1	**LEARNING OBJECTIVE:** A11: Compare and contrast reinsurance and primary reserving procedures.

SAMPLE ANSWERS

Candidates needed to demonstrate the presence of two of the following three issues:

Issue 1: Claim report lags to reinsurers are generally longer.

Sample Answer 1

Reinsurer would not know about claims 5 and 7. Claim 5 is likely to breach 50% of retention threshold and reinsurer would probably know about it a year later.

Sample Answer 2

Slow reporting lag – Reinsurer gets notified when Loss & ALAE hits 50% of retention which may take a while to develop (i.e. talc mass tort claims). They take a long time to develop (especially losses) so the primary might know of it way sooner than reinsurer.

Issue 2: There is persistent upward development of most claim reserves (often due to tendency to underestimate ALAE).

Sample Answer 1

Ratio of ALAE to Loss

Claim	Ratio
1	0.15
2	0.1241
3	0.1143
4	0.1083
5	0.1
6	0.0889
7	0.0682

There's an upward development of ALAE because ALAE tends to be under-reserved.

Sample Answer 2

ALAE / Loss

Claim	Ratio
1	0.15
2	0.124
3	0.114
4	0.108
5	0.1
6	0.089
7	0.068

Decreasing trend as you look down the table – There tends to be an upward development of reserves as primary insurers tend to underestimate LAE costs. AY 2014 claims have lower ALAE-to-Loss ratios than AY 2013, so they may be understated.

Issue 3: Heterogeneity of patterns.

Sample Answer 1

Each accident year has different retention, making patterns different and adding difficult

since there are only two accident years.

Sample Answer 2

Reinsurers have very heterogeneous exposures. Exposures vary by LOB, contract terms, etc. The retention changed in 2014, so historical losses before 2014 can't be directly used to compare with losses after 2014.

EXAMINERS' REPORT

- Candidates were expected to have an overview of reinsurance and primary insurance reserving methods, the assumptions underlying them, and how those assumptions could be violated due to differences in information available to reinsurers.
- Candidates often identified common issues with reinsurance data, but then had difficulty using the provided data to demonstrate the presence of these issues.
- The most common error was misinterpreting the information provided in the question as an actual report provided to the reinsurer. Therefore many candidates used "the reports the reinsurer receives may be lacking some important information" as an issue.
- Another common error was stating "there is a persistent upward development of most claim reserves" often due to the "tendency to under-reserve ALAE", but then not using the individual claims to show how the ALAE ratios were increasing with the age of the claim.

QUESTION 13	
TOTAL POINT VALUE: 1.75	**LEARNING OBJECTIVE:** A13: Calculate ceded loss reserves using appropriate methods.

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

	Adjusted Premium	Aggregate Loss Report Lag		Total Reported Loss	
	9,000	90%	=9,000*90%	6,000	
	12,000	70%		5,000	
	11,000	40%		2,000	
	13,000	30%		4,000	
	Used Up Premium		24,800	17,000	=6k+5k+2k+4k
	ELR		=17,000/24,800	=68.55%	
	Expected Loss		= ELR * Adj Prem * (1-Lag)		
	2011		0.61695		
	2012		2.4678		
	2013		4.5243		
	2014		6.23805		
	13.847 Million				

Sample Answer 2

	Adjusted Premium	Aggregate Loss Report Lag		Total Reported Loss	
2011	9,000	90%	=9,000*90%	6,000	
2012	12,000	70%		5,000	
2013	11,000	40%		2,000	
2014	13,000	30%		4,000	
	Used Up Premium		24,800	17,000	=6k+5k+2k+4k
		ELR	=17,000/24,800	=68.5%	
	Expected Loss		= ELR * Adj Prem * (1-Lag)		
		2011	0.6165		
		2012	2.466		
		2013	4.521		
		2014	6.2335		

13.837 Million
Part b: 0.5 point
Sample Answer 1 Adjust the ERPP to on-level premiums so that the loss ratio for each AY would be comparable. *Sample Answer 2* You need to adjust for varying rate levels because the SB method assumes a constant ELR across all years. *Sample Answer 3* Current rate level. We want all of the premiums to be on the same level because we are calculating a single ELR from all years. *Sample Answer 4* Adjusting for different rate levels is necessary as the losses that have yet to emerge will do so at today's cost levels. The adjusted premium should therefore give us a better estimate of the ELR in order to calculate IBNR.
EXAMINERS' REPORT
Candidates were required to complete an IBNR estimate using the Stanard-Bühlmann technique. The vast majority of candidates were able to do this successfully.
Part a
Candidates generally performed well on this part. Common mistakes included using Earned Risk Pure Premium instead of Adjusted Premium, as well as calculating IBNR by subtracting the reported losses from the expected ultimate losses.
Part b
The bulk of candidates correctly identified Current Rate Level as the required adjustment. Discussion of trend and other similar terms/concepts also earned credit. Candidates who mentioned adjusting for expenses and other similar terms/concepts did not receive any credit, as these adjustments are already included in the Earned Risk Pure Premium.

QUESTION 14

TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE:** A14: Forecast Premium Reserves.

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

PDLD(1) = [{Bp/(Sp*ELR%*L1)} + {(CL/L)*LCF}]*TM
= [{ .2/(.75*.8)} + {.85*1.2]*1.05
= 1.421

PDLD(2) = inc. cap * LCF * TM = .6 * 1.2 * 1.05 = .756

Sample Answer 2

PDLD(1) = {.2 + (.75*.8 *.85 * 1.2)}/(.8*.75) = .756

PDLD(2) = .6 * 1.2 * 1.05 = .756

Part b: 0.5 point

Sample Answer 1

1. Formula can reflect pricing parameters that are currently being sold.
2. PDLD ratios calculated by formula are more stable than those from empirical data.

Sample Answer 2

1. Terms of policies may have changed since historical policies were written. Using the retro rating formula makes the PDLD ratios better reflect current conditions.
2. Patterns in historical data can be extremely volatile making it difficult to make development pattern selections.

Part c: 0.75 point

Sample Answer 1

A push to settle small claims faster would increase the amount of claims in the early periods that fall within plan limitations since these are not subject to per occurrence limit. This would likely increase early PDLD ratios. On the other hand, settling small claims early makes later loss emergence is mostly from large claims, so the PDLD ratios for later adjustments will drop. This is because the large claim development likely occurs outside the plan parameters.

Sample Answer 2

Settling small claims faster (assuming small means below cap) will increase loss and capped loss by the same amount. So, ratio of CL/L will increase towards one. Earlier PDLD ratios will be higher. But, since later PDLD claims will now see only the larger claims (that can hit the cap) develop, those PDLD ratios will decrease. PDLD line segments get flatter faster basically, but start steeper.

EXAMINERS' REPORT

The candidates were expected to calculate the "Premium Development to Loss Development ratios" and the properties of these ratios under various conditions. Candidates generally scored well in part a wherein they had to calculate the ratios. However, the performance dipped when

they had to verbalize the relationships under different conditions in part b.

Part a

A majority of the candidates had a good understanding of this part.

- The candidate was expected to know how to calculate the "Premium Development" to "Loss Development" ratio at different points in the life-cycle of a retro rated policy.
- The candidate was expected to understand the data provided in the question, use the appropriate formulae, and compute the PDLD ratios at the first and second adjustment period correctly. Full credit was given if the candidates went straight to the computation without the intermediate step of writing down the formulae.
- A few candidates were unable to link the appropriate meaning to the values provided in the question and used them incorrectly.
- There were very few arithmetic errors.

Part b

This part was more challenging than part a.

- The candidate was expected to provide a brief description of two benefits of using a formula based approach to calculate PDLD ratios as against using an empirical "loss reported data history" as the basis.
- The candidate should have summarized the potential for a "responsive" method that facilitates the inclusion of the latest pricing mechanisms used in selling the policies and secondly the reduction in the volatility of the estimated ratios, when the process is driven by the "formula" method as against the "historical data" method.
- Many candidates were careless about the wording of their answers and did not relate the underlying factors in a correct and coherent manner.

Many candidates overlooked the fact that a time element was inevitable before the final closure of a retro treaty.

QUESTION 15	
TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE:** B2: Value the equity of a P&C insurer based on its expected future dividends, its free cash flow to equity, or its expected abnormal earnings.

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

K = .08

	2016	2017	2018
ROE =	10/100 = .1	12/105 = .114	13/107 = .121

V = 100,000 + (.1 - .08)(100,000)/1.08 + (.114 - .08)(105,000)/1.08^2 + (.121 - .08)(107,000)/1.08^3 + [(.121 - .08)(107,000)(1.03)/(.08-.03)]/1.08^3
= 100,000 + 8,395 + 71,740
= **180,135**

Sample Answer 2

AE_{2016} = 10,000 – 100,000 * 0.08 = 2,000
AE_{2017} = 12,000 – 107,000 * 0.08 = 3,600
AE_{2018} = 13,000 – 105,000 * 0.08 = 4,440

$V_0 = BV_0 + \sum AE/(1+k)^i$ + Terminal Value

= 100,000 + 2,000/1.08 + 3,600/1.08^2 + 4,440/1.08^3 + [4,440*1.03/(0.08-0.03)]/1.08^3
= **181,070**

Part b: 0.5 point

Sample Answer 1

V_0 = 100,000 + (.1 - .08)(100,000)/1.08 + (.114 - .08)(105,000)/1.08^2
+ (.121 - .08)(107,000)/1.08^3 + (.121 - .08)(107,000)(1.03)/1.08^4
+ (.121 - .08)(107,000)(1.03)^2/1.08^5 + (.121 - .08)(107,000)(1.03)^3/1.08^6
= 100,000 + 8,395 + 3,321 + 3,168 + 3,021
= **117,905**

Sample Answer 2

*V_0 = 100,000 + 2,000/1.08 + 3,600/1.08^2 + 4,440/1.08^3 + 4,440*1.03/1.08^4 + 4,440*1.03^2/1.08^5 + 4,440*1.03^3/1.08^6*
= ***118,088***

Part c: 0.5 point

Sample Answer 1

- *Scenario in part (b) is more realistic*
- *Abnormal earnings cannot be expected to continue in perpetuity*

Sample Answer 2

(b) is more realistic since maintaining abnormal earnings in perpetuity is not realistic in practice

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

EXAMINERS' REPORT
Overall, candidates performed rather well on this question. Candidates were expected to know how to calculate abnormal earnings and apply them to the abnormal earnings method in the estimation of company value. Candidates lost credit if they based the required shareholder return on the minimum capital requirement rather than the beginning GAAP equity. In addition, many candidates assumed that the abnormal earnings tended towards zero on a linear basis rather than a one-time decrease to $0. Many candidates also lost points as they failed to include the initial book value in the final calculation.
Part a
Candidates were expected to apply the abnormal earnings method to provide an estimate of company value. In order to receive full credit, candidates were required to show the appropriate calculation of abnormal earnings discounted at a rate of 8%. In addition, candidates were required to calculate the appropriate discounted terminal value since the abnormal earnings were projected to go into perpetuity. Many candidates performed very well. A common mistake was estimating the abnormal earnings based on the minimal capital requirement rather than beginning GAAP equity. Many candidates also failed to add the original book value to the value contemplated by the abnormal earnings.
Part b
Part b is an extension of part a, and again, many candidates performed well. In order to receive full credit, candidates were expected to adjust the 2018 abnormal earnings by 3% per annum and discount it using an 8% discount rate. Candidates who did not receive full credit typically assumed that the abnormal earnings would gradually trend to zero linearly.
Part c
Candidates performed very well on this question part. Candidates were expected to understand that it is not realistic to assume that abnormal earning to continue into perpetuity.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

QUESTION 16	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** B2: Value the equity of a P&C insurer based on its expected future dividends, its free cash flow to equity, or its expected abnormal earnings.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answer 1

Free cash flow: all cash that could be paid out to the firm's sources of capital, whether or not it is actually paid out in the period it is generated measured net of any amounts required to be reinvested in the firm to maintain operations and generate growth at the rate assumed in the forecasts.

Sample Answer 2

Free cash flow is the money that can be paid as dividend it's usually net of any cash flow that required to invest for operation and company growth

Part b: 0.25 point

Sample Answer 1

DCF methods require forecasting and modifying financial statements, the resulting measure may be unfamiliar to management.

Sample Answer 2

It uses adjusted accounting measures which does not in-line with balance sheet or any financial statement and hence hard to understand/reconcile for management.

Sample Answer 3

It has a large terminal value. Thus it puts a lot of weight on expected growth rate and discount rate.

Part c: 0.5 point

Sample Answer 1

Usually DCF method assumes the free cash flow grows in perpetuity, this is unlikely given competitors will enter the market and squeeze the profit. Abnormal earnings method, instead, only assume the abnormal earning exist for a period of time, which is more realistic.

Sample Answer 2

Abnormal earnings calculates firm value directly using accounting measures, will not need to adjust into a cash flow measure.

EXAMINERS' REPORT

This question was challenging in that it was asking for more qualitative details of the Goldfarb paper. Whereas the paper focuses on calculation, this question focused on being able to explain some of the implications of those calculations and formulas. This required either a very strong

understanding of the nuances of the methods or a very detailed memorization of the paper.

Part a

- Candidates were expected to include at least the portion of the definition of free cash flow that described FCF as money available to pay dividends.
- To receive full credit, candidates also had to state that the amount is net of funds required for reinvestment in the company to support normal operations and forecasted growth.
- Common errors included giving the definition of the Free Cash Flow on Equity, which was more specific than the general definition we were looking for. Candidates also commonly did not state that the amount was net of amounts needed to support growth and general operations.

Part b

- Candidates were expected to state that due to the many adjustments needed to convert the accounting measures to cash flows, the results may not be familiar to management.
- This part was only a quarter point, so there was no partial credit.
- The most common incorrect response was to state that a weakness of the method was that you have to project financial values into the future.

Part c

- The abnormal earnings method is an improvement over the discounted cash flow method because it uses values directly from the income statement without adjustment. We also gave credit for explanations that argued that abnormal earnings is an improvement over DCF because DCF assumes growth in perpetuity, whereas abnormal earnings are assumed to converge to 0 over a finite horizon, which is more reasonable.
- To get full credit for the second option, the candidate must have explicitly stated that the assumption of the abnormal earnings approach is more reasonable.
- Common incorrect answers included stating that abnormal earnings focus on the source of value creation and DCF focuses on the effect of value creation, with no further explanation of why this is an improvement. Many candidates also discussed the reduced weight that the abnormal earnings method puts on the tail value, without explanation of why that was an improvement (some credit was given for this response).
- Several candidates approached this part by simply stating what they knew about the two methods. An answer receiving full credit, however, provided a comparison of the methods and demonstrated an understanding of the advantages and disadvantages of the methods.

QUESTION 17	
TOTAL POINT VALUE: 3.5	**LEARNING OBJECTIVE:** B2: Value the equity of a P&C insurer based on its expected future dividends, its free cash flow to equity, or its expected abnormal earnings.

SAMPLE ANSWERS

Part a: 2.25 points

Sample Answer 1

k = 0.032 + 0.04 * 0.75 = 0.062
g = .4 * .1 = 0.04

Year	Dividend
15	15,200 * .6 = 9,120
16	9,660
17	10,380
18	11,100

$9,120/1.062 + 9,660/1.062^2 + 10,380/1.062^3 + (11,100/1.062^4)[1 + 1.04/(.062-.04)]$
= 447,055.92

Sample Answer 2

growth rate g = plowback * ROE = (1 – 60%) * 10% = 4%
discount rate k = 3.2% + 0.75 * 4% = 6.2%

Year	Dividend ($000)
2015	15,200 * 60% = 9120
2016	16,100 * 60% = 9660
2017	10,380 * 60% = 10380
2018	18,500 * 60% = 11100

$PV(Dividend) = 9,120/1.062 + 9,660/1.062^2 + 10,380/1.062^3 + 11,100/1.062^4$
= 34,544.88 ($000)
Terminal Value = 11100 * (1 + 4%) / (6.2% - 4%)
= 524,727.27 ($000)
Company Value = $(34544.88 + 524727.27/1.062^4) * 1000$
= 447,055,915

Part b: 0.5 point

Sample Answer 1

May need to adjust the industry beta to reflect firm specific characteristics like:
1.) leverage / debt : equity
2.) mix of business / lines written

Sample Answer 2

2 considerations when using industry β:
mix of business: make sure to use companies with similar mix only

financial leverage: use an all-equity β reflecting business risk but not debt leverage

Part c: 0.75 point

Sample Answer 1

Since the firm's growth rate of 4% is less than the industry average of 5.5%, this suggests the firm may be less risky than the industry average, so the lower beta of .75 compared to the industry is reasonable.

Sample Answer 2

Company β < Industry
Company g < Industry
Firm is growing slower, implying less potential for risk. It makes sense the firm's β would be smaller than the industry

EXAMINERS' REPORT

Part a

Candidates were expected to apply the dividend discount model (DDM) to estimate the value of a company. To obtain full credit, candidates were expected to clearly present the correct formulas/values for the dividends during the forecast horizon, the terminal value, and the overall firm value. Most candidates performed very well on this question. The following errors were typical of candidates who did not receive full credit:

- Minor arithmetic mistakes / transcription errors
- Using net income for the cash flows instead of the dividends (not applying the dividend ratio)
- Using the industry beta to compute the discount rate (without sufficient justification)
- Using the industry growth rate for the terminal value (without sufficient justification)

Part b

Candidates were asked to briefly describe two considerations when using an industry beta. Most candidates were able to provide at least one of these considerations, but the majority of candidates did not identify both of them. Incorrect responses commonly made reference to growth rates, investment portfolios, ROE's, and company size.

Part c

This question part required candidates to synthesize readily available information to assess the reasonableness of the company beta. Candidates generally performed very well on this part. Most candidates were able to provide an appropriate assessment. Candidates who did not receive full credit often had correct assessments with incomplete explanations. The following errors were common:

- Not clearly explaining that a higher growth rate is indicative of a riskier firm (warranting a higher beta)
- Providing a general explanation of the situation without clearly committing to an assessment of the reasonableness of the company beta

Candidates who incorrectly calculated a higher growth rate for the company in their response to part a were not penalized for providing the opposite answer in this question part, provided that their logic was correct and sufficiently delineated.

QUESTION 18	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE:** C1: Demonstrate how insurance and financial risk can be analyzed quantitatively.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

The minimum variance occurs when the frequency -> ∞ causing the process variance to go away

$$\lim_{\lambda_i \to \infty} Var\left[\frac{\beta X_i}{E[\beta_i X_i]}\right] = \lim_{\lambda_i \to \infty}\left[(1+b_i)\left(\frac{\mu_i^2 + ó_i^2}{\lambda_i^2} + c_i\right) + b_i\right] = (1+b_i)c_i + b_i = c_i + b_i c_i + b_i$$

Sample Answer 2

Minimum variance when expected # of claims goes to infinity i.e. $\lambda_i \to \infty$

minimum ($Var\left[\frac{\beta X_i}{E[\beta_i X_i]}\right]$)= $(1+b_i)c_i + b_i$

Part b: 0.25 point

Sample Answer 1

What this indicates is that regardless of size, even if when λ-> ∞ and the maximum effect of the law of large numbers is achieved, there is always some variance that occur for a single line of business

Sample Answer 2

If you increase the size of your book (increase λ) a lot, there is a minimum level of variance you will still have, cant lower it any more limit to diversification benefit

Sample Answer 3

lowest possible variance for this line of business

Part c: 0.25 point

Sample Answer 1

The parameter c_i represents the correlation between the claims within the given line(i), it determines the spread of claims within lines

Sample Answer 2

affects the correlation of losses within a LOB

Sample Answer 3

c affects the mean for claim counts, if c is large the frequency will have larger variance

Part d: 0.25 point

Sample Answer 1

The correlation identified with b_i affects the correlation between line of business

Sample Answer 2

Affects the correlation of losses between LOB

Sample Answer 3

This is the correlation of the loss ratios by line

Sample Answer 4

b is correlated to the loss distribution, varying b will vary the percentile selected

Sample Answer 5

b correlates line I with the total company result, the larger the b the more correlated (inflationary effects)

Sample Answer 6

External system's correlation

Part e: 0.75 point

Sample Answer 1

$\sqrt{b_i} = 0.04$*;* $b_i = 0.0016$;

Var= 0.3^2= $c_i + b_i + \ b_i\, c_i$ *;*

0.09= $c_i(1.0016) + 0.0016$-> $c_i = 0.0883$

Sample Answer 2

0.3^2=0.04^2+c_i+0.04^2c_i $\quad b_i = 0.04^2 = 0.016 \quad c_i = 0.0883$

EXAMINERS' REPORT

The key to this problem was to be able to interpret the formula provided: for example, parts a & b required the candidates to understand that no matter how large λ is (meaning that the line is so large that there are many claim counts), there is a minimum to the variance of that line's loss ratio.

Candidates typically earned little credit on this question as a whole.

Part a

Only a few candidates seemed to know which parameter could be varied to derive the minimum variance.

Part b

Only a few candidates seemed to understand that the implication of the answer in part a was that the variance couldn't go below zero.

Parts c & d

Very few candidates could correctly interpret the role of b_i and c_i in the variance formula.

Part e

Even among those candidates who could derive the minimum variance formula in part a, very few could use it to plug values in where provided to solve for the remaining quantities.

QUESTION 19	
TOTAL POINT VALUE: 1.25	**LEARNING OBJECTIVE:** C1: Demonstrate how insurance and financial risk can be analyzed quantitatively. C8: Evaluate best practices in risk measurement, modeling, and management of various financial and non-financial risks faced by an entity.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answer 1

While reinsurer A has a better knowledge of property reinsurance, it is also much more vulnerable to catastrophe risk as it could affect a large portion of its portfolio at once. This would not be the case for reinsurer B as geographical and line of business diversification would lessen the impact of a catastrophe (even though casualty reinsurance would still be highly correlated in the event of a large catastrophe). With these considerations in mind reinsurer A would require a higher reinsurance risk margin for the primary insurer's capital requirements.

Sample Answer 2

Both are similar financially but are in different industries. Reinsurer B will be diversified since a cat event will impact both a primary property insurer and property reinsurer. The risk measure should be lower using company B over company A. Same with the required surplus.

Part b: 0.5 point

Sample Answer 1

This increases counterparty risk and the amount of capital that must be held to cover that risk. Separating the reinsurance agreement could help lower the capital requirement for that risk as it reduces the insurer's exposure to its reinsurer's failure.

Sample Answer 2

Assuming losses between these reinsurers are not completely dependent, it may be more optimal to spread coverage between multiple reinsurers to lower credit risk. This would allow the insurer to hold less capital for credit risk.

EXAMINERS' REPORT

Candidates were expected to know some basic concepts and best practices in ERM models. Candidates generally performed well on this question and were able to recognize the major issues presented by the problem. Where candidates struggled was with more subtle parts of the question.

Part a

Most candidates recognized and explicitly stated that the correlation between the underwriting exposures for the primary insurer and reinsurer A would lead to the capital model indicating more surplus should be held if the reinsurance coverage were placed with reinsurer A. Candidates struggled to make explicit that this correlation is stronger in the far right tail of the distribution with which capital models are generally more concerned. Given that the scenario presented involved catastrophe reinsurance, this was implicit in some responses, but the tail of the

distribution for an insurer and reinsurer do not always overlap so well.

One mistake several candidates made was in mentioning underwriting guidance, which is given as a reason for purchasing reinsurance in the Patrik paper. While this is in some cases useful, if it is at all quantified in the capital model, it is far lower in magnitude than the correlation of underwriting exposures in the tail. Several candidates mentioned that property reinsurance was more likely to lead to a generally quicker bankruptcy than latent claims which, while true, ignores the more salient point of the correlation in tail exposures.

Part b

In part b, most candidates recognized that placing coverage among multiple reinsurers *may* lead to some net benefit. Diversifying coverage is less risky in parts of the model, but given the issues in part a, placing any reinsurance with reinsurer A will lead to higher indicated surplus in other parts of the model. Whether or not this is a net benefit overall depends on the model. Several candidates stated that diversification was always unconditionally good, which is incorrect. Some candidates appeared to misinterpret "100% of the coverage" as fully ceded property premium and gave a response relating to return on capital.

QUESTION 20

TOTAL POINT VALUE: 3	**LEARNING OBJECTIVE:** C1: Demonstrate how insurance and financial risk can be analyzed quantitatively. C4: Demonstrate the properties of various risk measures and their limitations. C8: Evaluate best practices in risk measurement, modeling, and management of various financial and non-financial risks faced by an entity

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

$$TVaR_\alpha(X_{Gross}) = VaR_\alpha(X_{Gross}) + \frac{E[X_{Gross}] - E[X_{Gross} \wedge VaR_\alpha(X_{Gross})]}{1-\alpha} = 50M + \frac{20M - 8M}{1-0.9} = 170M$$

$$TVaR_\alpha(X_{Cede}) = VaR_\alpha(X_{Cede}) + \frac{E[X_{Cede}] - E[X_{Cede} \wedge VaR_\alpha(X_{Cedes})]}{1-\alpha} = \frac{7.5M}{1-\alpha} = 75M$$

Net capital requirement $= TVaR_\alpha(X_{Gross}) - (1-\theta) * TVaR_\alpha(X_{Cede}) = 170M - (1-0.6) * 75M = 140M$

Sample Answer 2

$$TVaR_\alpha(X_{Net}) = VaR_\alpha(X_{Net}) + \frac{E[X_{Net}] - E[X_{Net} \wedge VaR_\alpha(X_{Net})]}{1-\alpha} = 50M + \frac{20M - 7.5M - 8M}{1-0.9} = 95M$$

$$TVaR_\alpha(X_{Cede}) = VaR_\alpha(X_{Cede}) + \frac{E[X_{Cede}] - E[X_{Cede} \wedge VaR_\alpha(X_{Cedes})]}{1-\alpha} = \frac{7.5M}{1-\alpha} = 75M$$

Net capital requirement $= TVaR_\alpha(X_{Net}) + \theta * TVaR_\alpha(X_{Cede}) = 95M + 0.6 * 75M = 140M$

Sample Answer 3

$$TVaR_\alpha(X_{Gross}) = VaR_\alpha(X_{Gross}) + \frac{E[X_{Gross}] - E[X_{Gross} \wedge VaR_\alpha(X_{Gross})]}{1-\alpha} = 50M + \frac{20M - 8M}{1-0.9} = 170M$$

$$TVaR_\alpha(X_{Net}) = VaR_\alpha(X_{Net}) + \frac{E[X_{Net}] - E[X_{Net} \wedge VaR_\alpha(X_{Net})]}{1-\alpha} = 50M + \frac{20M - 7.5M - 8M}{1-0.9} = 95M$$

$$TVaR_\alpha(X_{Cede}) = TVaR_\alpha(X_{Gross}) - TVaR_\alpha(X_{Net}) = 170M - 95M = 75M$$

Net capital requirement $= TVaR_\alpha(X_{Gross}) - (1-\theta) * TVaR_\alpha(X_{Cede}) = 170M - (1-0.6) * 75M = 140M$

Part b: 0.75 point

Sample Answer 1

$$TVaR_{\alpha}(X_{Gross}) = VaR_{\alpha}(X_{Gross}) + \frac{E[X_{Gross}] - E[X_{Gross} \wedge VaR_{\alpha}(X_{Gross})]}{1-\alpha} = 50M + \frac{20M - 8M}{1-0.9} = 170M$$

$$TVaR_{\alpha}(X_{Cede}) = 0.4 * TVaR_{\alpha}(X_{Gross}) = 0.4 * 170M = 68M$$

Net capital requirement

$$= TVaR_{\alpha}(X_{Gross}) - (1-\theta) * TVaR_{\alpha}(X_{Cede}) = 170M - (1-0.6) * 68M = 142.8M$$

Sample Answer 2

Note on other accepted answers:
If Gross TVaR was miscalculated in Part A (e.g. 120 instead of 170), then 120 was treated as correct in Part B and full credit was given in Part B for answers based on that 120.

Part c: 0.5 point

Sample Answer 1

The complexity of reinsurance contracts makes it harder to calculate the impact of loss. XS loss does not have a linear relationship with the underlying risks.

Sample Answer 2

Some reinsurance contracts do not warrant a credit to the insurer's risk – likely done for tax reasons.

Part d: 0.5 point

Sample Answer 1

Reduce concentration risk – diversify its reinsurance contract with many reinsurers in many different regions.

Sample Answer 2

Choose reins. with good credit ratings to reduce default risk.

EXAMINERS' REPORT

- Candidate were expected to know terms of insurance and financial risk, know the properties of various risk measures and their limitations (e.g. TVaR), and know best practices in measurement, modeling, and managing of risk.
- Candidates generally struggled on Parts a and b – application of risk measures – and scored well on Parts c and d – conceptual understanding of managing insurance and financial risk.
- The individual calculations of TVaR were straightforward, but the application of those individual TVaR calculations into the net capital requirement (based on the specifics of the reinsurance contracts) was a challenge for many candidates.
    - Some candidates misapplied the 90% factor for TVaR, by either multiplying by 0.9 or dividing by 0.9, instead of dividing by (1-0.9)
    - There was also some misunderstanding on the relationship of net, ceded, and gross, and how a recoverable credit risk charge should be applied.

Part a

Candidates struggled with this question. It was common that the candidates did not know the formulas used to calculate TVaR and the Net Capital Requirement. It was common that the candidates did not enter the proper values into the calculation of TVaR and the Net Capital

Requirement.
Part b
Same comments as for part a above.
Part c
Candidates generally did well on this question.
Part d
Candidates generally did well on this question.

QUESTION 21	
TOTAL POINT VALUE: 1	**LEARNING OBJECTIVE:** C3: Evaluate and select appropriate models to handle diverse risks, including stochastic approaches.

SAMPLE ANSWERS (BY PART, AS APPLICABLE)

Part a: 0.5 point

Sample Answer 1

- A copula can join any distributions, regardless of what family they are from
- A copula can reflect increased correlation between the distribution in the tail

Sample Answer 2

- Copulas allow for recognition of varying correlations at different levels of a distribution. This helps for modelling risks that aren't always correlated, but are in the tail.
- Copulas also facilitate simulations of events, which can help in understanding how to mitigate risks.

Sample Answer 3:

- Forces correlations between marginal distributions without making any assumptions regarding causality.
- Provides significant flexibility in quantifying tail exposure, which is an effective ERM approach.

Other accepted responses – any two of the following received full credit

- Copulas can join any two distributions and show this without needing to disclose the underlying distributions (so can keep proprietary info safe but still show correlation) Quantify correlation along entire distribution
- Copulas can be used to report dependencies to external parties (maybe a rating agency) without giving away the underlying distribution of losses)
- It allows for the creation of graphs using various statistics along the distribution
- As opposed to scatterplots, provides a measure of the correlation between the joined variables.
- Can select a copula based on the correlation want to use. Heavy in the right tail, just use a copula with heavy dependencies in the right tail, etc.
- Allows for nonlinear correlations. For example, in insurance some lines may be loosly correlated at small percentiles, while being heavily correlated in the tail.

Part b: 0.5 point

Sample Answer 1

I would use the Heavy Right Tail Copula (HRT). This copula has a light left tail and a heavy right tail, so it will reflect the increase in correlation of insurance losses in the righty tail (during extreme events).

Sample Answer 2

We could use a Gumbel copula since it has a heavier right tail than the Normal copula, this can better reflect the skewness of insurance losses.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

EXAMINERS' REPORT
Most candidates performed very well on this question, as it tested basic concepts regarding copulas.
Part a
The vast majority of candidates received full credit; almost all candidates received at least some credit. In order to receive full credit candidates needed to provide two distinct benefits of using copulas. Some candidates did not receive full credit when the second benefit they listed was essentially the same as the first benefit.
Part b
Over 95% of candidates received full credit on this part. The candidate needed to recall one copula that is more appropriate for modeling insurance than the Normal copula and briefly describe why it is better. The most common error for this problem was candidates who mistakenly selected Frank's Copula as having a fatter tail than the Normal, which is incorrect. Other candidates only named a copula and failed to describe a feature of the chosen copula that would make it more appropriate than a Normal one.

QUESTION 22	
TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE**: C2: Describe the use of enterprise-wide risk modeling and aggregation techniques.

SAMPLE ANSWERS

Part a: 1.5 points

Sample Answer 1

Model Risk – models can't fully capture the complexity of the insurance process.
Estimation Risk – historical data may not be enough to accurately estimate model parameters.
Projection Risk – parameter estimates may not be equal to historical estimates for projection period due to trend / inflation.

Sample Answer 2

Model Risk – risk that models can't accurately describe insurance process / data
Parameter Risk – risk associated with identifying and estimating predictors of claims
Structural Risk – risk that parameters vary with time.

Sample Answer 3

Specification Risk – risk that the model cannot accurately model the insurance process.
Parameter Selection Risk – risk that not all parameters / trends can be properly identified.
Data Error – risk that the data is not credible or the person analyzing the data does not fully understand it.

Sample Answer 4

Model Selection – whether the model selected accurately reflects the insurance losses given that it is based on a sample.
Parameter Selection – whether the parameters selected are appropriate to match the real world experience
Extreme Events – events will impact the uncertainty of the modeling process. Ex: catastrophes

Part b: 0.75 point

Sample Answer 1

Use distribution with heavier tails to model extreme loss nature of cat exposed HO losses
Use more years of historical data / industry data to increase credibility of data used for parameter selection
Adjust parameter estimates using judgment to reflect effect of coverage trigger on loss distribution for projected period.

Sample Answer 2

Model Risk – normal may not reflect skewness of insurance process – could use lognormal
Parameter Risk – could look at longer historical period of internal data or combine with industry data.
Structural Risk – due to court ruling, historical parameters need adjusting (at least for largest state)

Sample Answer 3

Specification – Use a lognormal distribution to model losses. This is asymmetric and better fits insurance losses than normal.

Parameter selection error – incorporate the effect of the court ruling into a parameter in the model to increase accuracy of expected future losses.

Data Error – Use ten years of internal loss experience instead of five to increase credibility.

Sample Answer 4

Model Selection: Normal distribution might not be the best. It is symmetric and doesn't have fat tails. Could consider using lognormal which is better at capturing losses at higher probabilities.

Parameter Selection – Use a longer history than five years, or use external loss data as well to reduce uncertainty about parameters.

Extreme Events – recent court ruling could be considered an extreme event. Actuary should adjust past data for the new coverage trigger so that the model is accurate going forward.

EXAMINERS' REPORT

Candidates were expected to know some basic concepts in ERM models and specifically the loss modeling process. Candidates generally performed well.

Part a

Most candidates were able to identify and describe three key elements of uncertainty inherent in the loss modeling process. While these show up on the syllabus with various names, any valid identification was accepted for full credit. For example, Model Risk, Model Error, and Specification Error each identify one of the key elements. Where a candidate would not have received full credit was using a simple restatement of the identification as the brief description of the key element. Several candidates mentioned process risk or volatility, which is a key part of insurance risk but is not a key element of uncertainty in the loss modeling process.

Part b

This part of the question required candidates to apply a simple scenario to the key elements of uncertainty from part a. The three improvements from the scenario were to use a distribution other than normal (model risk), use more or less years of data depending on volume or use external data (parameter risk), and to adjust losses for the court ruling (structural risk). Even where candidates erred in part a, many were able to provide improvements in part b that earned credit.

QUESTION 23

TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE:** C2: Describe the use of enterprise-wide risk modeling and aggregation techniques. C3: Evaluate and select appropriate models to handle diverse risks, including stochastic approaches.

SAMPLE ANSWERS

Part a: 1.5 point

Sample Answer 1

Year	x	y
2010	-7.2	-0.6
2011	-3.2	-7.6
2012	-0.2	-3.6
2013	-4.2	-2.6
2014	14.8	14.4

$\text{rho} = \text{p} = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$

$\overline{\text{A}}$ = 22.2

$\overline{\text{B}}$ = 30.6

∑xy = 253.4; $\sum x^2$ = 298.8; $\sum y^2$ = 285.2

p = 0.868

Sample Answer 2

$\text{rho} = \text{p} = \frac{E[XY] - E[X] \times E[Y]}{\sigma_x \times \sigma_y}$

E[X] = 22.2

E[Y] = 30.6

E[XY] = 730

σ_x = 7.73; σ_y = 7.55

p = 0.868

Part b: 0.75 point

Sample Answer 1

Rank A	Rank B	(Rank A – Rank B)^2
1	4	9
3	1	4
4	2	4
2	3	1
5	5	0
		s = 18

T = 1 - $\frac{S}{n(n^2-1)/6}$ = 1 - $\frac{18}{5(5^2-1)/6}$ = 1 – 0.9 = 0.1

Sample Answer 2

AY	State A Rank	State B Rank	Diff	Diff^2
10	1	4	3	9
11	3	1	2	4
12	4	2	2	4
13	2	3	1	1
14	5	5	0	0

n=5 sum =18

$$\rho = 1 - \frac{S}{n(n^2-1)/6}$$

ρ = 1- (18*6)/(5(5^2-1)) = 0.1

Part c: 0.5 point

Sample Answer 1

The Pearson calculation uses values, and squares them, while spearman simply uses rank. This causes Pearson to give disproportionate weight to extreme values, like those seen in AY 2014.

Sample Answer 2

Pearson is affected by the value of the figures because it is cardinal. Spearman is ordinal, it depends only on rank. Pearson's correlation is high because it is affected by the outlier pair, 2014. Spearman is not.

Sample Answer 3

Pearson's suggests high correlation b/c depends on actual values and difference from means. The high outliers in 2014 (both states have highest) and the squaring of difference from means leads to such high correlation. Spearman's depends on rank and not values. Therefore, it is much lower and more accurate than Pearson's which is driven by outliers in 2014.

Sample Answer 4

Pearson correlation is a cardinal measure, and is largely affected by outliers. Spearman correlation is an ordinal measure and not affected by outliers. 2014 is considered as outliers, which largely impacts Pearson correlation

EXAMINERS' REPORT

Candidates were expected to calculate Pearson's Product-Moment correlation and Spearman's correlation, and then explain the apparent discrepancy between the 2 measures.

Overall, candidates performed quite well on this question.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

Part a
Candidates were expected to know how to calculate Pearson's product-moment correlation. Most candidates either received full credit or made a minor calculation error. It is possible to calculate Pearson's correlation entirely on a calculator. This earned full credit; however, partial credit is cannot be earned, so candidates who chose to do calculate the correlation entirely by calculator risked earning no credit by not showing all work.
Part b
Candidates were expected to know how to calculate Spearman's correlation. Most candidates earned full credit, and the majority who did not made minor calculation errors.
Part c
Candidates were expected to know that Pearson's is cardinal, while Spearman's is ordinal. Since the Pearson measure is sensitive to outliers, the large values in 2014 were skewing Pearson's correlation. Mention of all these points was necessary for full credit. Most candidates knew that Pearson's was cardinal, and Spearman's was ordinal. However, almost half of the candidates did not mention that 2014 was an outlier, which was causing the discrepancy.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

QUESTION 24	
TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE:** C4: Demonstrate the properties of various risk measures and their limitations. C5: Describe how risk measures and risk modeling, including allocation, can affect strategic management.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answers for the Definition

VaR at α is the specified value at the α percentile.

VaR = E[X | X = α]

Sample Answers for the Limitation

It is a single point, so it does not provide much information on the distribution.

It is not sub-additive, so does not provide diversification benefit.

It is only one point, and does not account for risk in the tail, or below the VaR. These risks are important in a risk management context.

Part b: 0.75 point

Sample Answers for the Definition

TVaR is the expected value of losses above a specified percentile of the distribution.

T Var = E[X | X > α]

Sample Answers for the Limitation

TVaR is linear in the tail and as a result does not reflect the risk averse attitude that a risk twice as large is considered more than twice as bad.

This ignores risk below α, where the risks may not be extreme, but could still be significant.

Part c: 0.75 point

Sample Answers for the Definition

RTVaR = TVaR + c * std dev (X | X> α), where c is some constant

RTVaR is the TVaR plus some proportion of the standard deviation in the tail.

Sample Answers for the Limitation

A limitation of RTVaR is that it only provides a calculation based on the tail losses & does not evaluate all losses in the distribution, meaning it is not a complete risk measure.

For a skewed distribution, the standard deviation loading may not provide enough weight in the tail.

A criticism of RTVaR is that even with the inclusion of standard deviation it may not place sufficient weight on very large losses due to being a quadratic measure.

EXAMINERS' REPORT

Candidates scored generally well on this question. To receive full credit on each part, candidates had to (1) provide a valid definition for the given risk measure, either in words or in a formula and (2) provide a valid limitation to that risk measure, with a brief explanation. Candidates generally performed well on this question, though part c proved more challenging than parts a and b.

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

Part a
Candidates scored well on this part. The most common error was to state a limitation without any explanation (this earned partial credit).
Part b
Candidates also scored well on this part. Common errors included: • Stating as a limitation that the risk measure includes losses excess of insolvency. The paper mentions this, but goes on to explain that it is not actually a limitation. • Stating a limitation without explanation (this earned partial credit).
Part c
Candidates found this part more challenging than parts a and b. Common errors included: • Confusion with WTVAR. • Forgetting the constant "c" applied to the standard deviation in the formula. • Stating a limitation without explanation (this earned partial credit).

QUESTION 25	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE:** C6: Describe the rationale for, methods for, and effect of managing insurance and financial risk.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

Underwriting risk is the risk associated with writing insurance. It encompasses many things, including product design risk, inadequate reserve/premium risk, accumulation risk, catastrophe risk, policyholder behavior risk, etc. The crux is having inadequate premium to cover the exposure.

Liquidity risk is the risk of having insufficient liquid assets to be able to meet a sudden cash demand.

Sample Answer 2

Underwriting risk is the risk that we are not writing business at the profit we need to obtain. Could be due to pricing inadequacies or mix of business issues.

Liquidity risk is the risk that we will not have enough funds to cover our liabilities that become due, and cannot meet current obligations.

Part b: 0.75 point

Sample Answer 1

A hurricane hitting the East Coast is the scenario we will consider. For a property insurer, this will create a big cash demand, as there will be many policyholders affected and claims will increase. Claims are part of underwriting risk. The company may have more than enough assets to meet these payments, but if the assets are not liquid or cannot be converted to cash at their full value, then there is a liquidity risk and the company may not be able to pay their policyholders within a reasonable timeframe.

Sample Answer 2

A major economic downturn or financial crisis

- Policyholders for certain lines of business (e.g. Worker's Compensation) may submit many more claims than expected, and the higher frequency is not considered in the pricing, leading to an underwriting loss.
- The higher-than-expected claims volume leads to a demand for payment in a shorter period of time, possibly forcing the company to liquidate assets at a discount

Sample Answer 3

Insurance industry becomes aware of latent claim risk, such as asbestos

- Newly-discovered cause of claims was not accounted for when policies were priced and sold, leading to an underwriting loss
- Many claims caused by this latent risk source are reported in a short period, leading to a large demand for payment from the insurance company, which is forced to liquidate assets at a discount to meet demands.

Part c: 0.75 point

EXAM 7 SPRING 2015 SAMPLE ANSWERS AND EXAMINERS' REPORT

Sample Answer 1

One mitigation strategy would be to purchase catastrophe reinsurance. This would reduce underwriting risk by reducing the potential for losses due to a catastrophic event. It reduces liquidity risk since the reinsurer will pay some of the losses and the primary will not need to come up with cash as quickly (spreads risk over time by paying reinsurance premiums).

Sample Answer 2

The company could issue a catastrophe bond. In the event of a large hurricane/earthquake, the investors' principal covers a significant portion of the loss, reducing the underwriting risk. It provides an influx of liquid assets to address the heightened demand for claim payment.

EXAMINERS' REPORT

In general, candidates performed fairly well on this question, though parts b and c were more challenging than part a. Some candidates did not fully understand how liquidity risk arises from the event scenarios they described, and they frequently had difficulty coming up with a risk mitigation strategy to reduce liquidity risk.

Part a

Candidates were expected to know the definitions of underwriting and liquidity risk. Candidates generally performed very well on this question, particularly the definition of underwriting risk. The most common error was stating that liquidity risk arises from "insufficient assets" without specifying that those assets must be liquid. Some candidates referred to liquidating assets before their maturity; however, the real risk is not being able to sell the assets for their full value.

Part b

Candidates were expected to identify a single event that would affect both underwriting and liquidity risk. Most candidates were able to identify such an event, but some struggled to adequately explain how the event would impact each type of risk. In attempting to describe the impact, some candidates failed to describe how the event would cause an increased demand for liquid assets.

Part c

Candidates were expected to provide a risk mitigation strategy to reduce the two types of risk. This was the most challenging part of the question. Most candidates provided a strategy, but sometimes the strategy only addressed one of underwriting and liquidity risk without addressing the other.

QUESTION 26	
TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE:** C6: Describe the rationale for, methods for, and effect of managing insurance and financial risks.

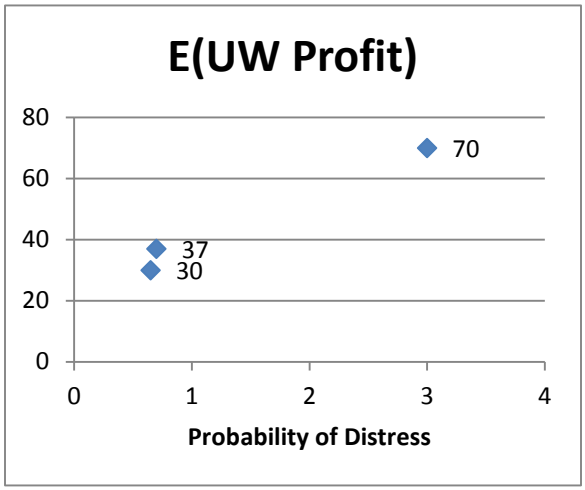
SAMPLE ANSWERS

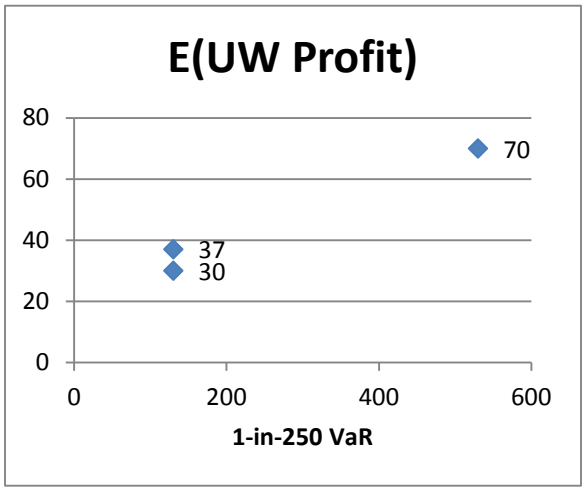
Part a: 1.5 points

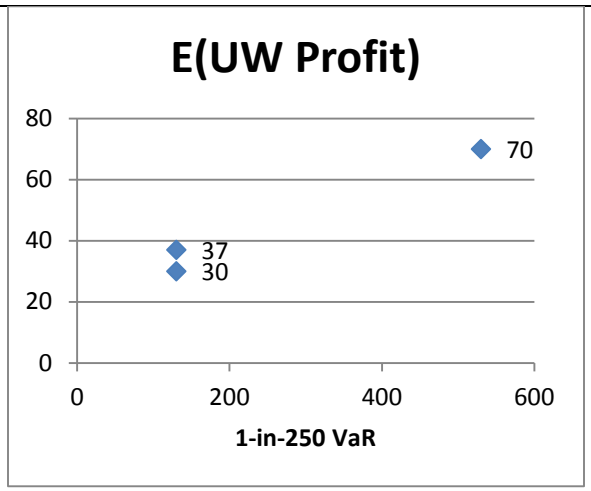
Sample Answer 1

Based on probability of distress and TVAR graphs, it's unclear which option is preferred, if any. Would be a management decision.

Looking at the VAR frontier, Option 1 is clearly better because it has a higher U/W profit for same amount of VAR.







Sample Answer 2

(The same graphs were created as above. The candidate's conclusion sentences follow.)

Probability of Distress: No conclusion if either reinsurance option is better since option 1 has both higher risk measure and higher profit.

1-in-250 VaR: For same risk measure but with more profit, option 1 is better than option 2.

1-in-100 TVaR: No conclusion for same reason as probability of distress.

Part b: 1 point

Sample Answer 1

	Gross	Option 1	Option 2
Capital	570	220	210
Cost of Capital	57	22	21
Savings in Cost	0	35	36
Net Reinsurance Cost		33	40
		2	-4

Option 1 more preferable.

Sample Answer 2

	Gross	Option 1	Option 2
Reinsurance Cost	0	33	40
Required Capital	570	220	210
Cost of Capital	57	22	21
Total Cost	57	55	61

Option 1 is better since it has a lower cost.

Sample Answer 3

	Gross	Option 1	Option 2
Risk Capital	570	220	210
Cost of Capital	57	22	21
Expected Net Profit	70	37	30
Adjusted Profit including Cost of Capital	13	15	9

Choose Option 1 – maximizes profit with cost of capital accounted for.

EXAMINERS' REPORT

Part a

Candidates had difficulty with this question part. The most common mistake was to examine only one risk measure. Another less common mistake was to analyze all three risk measures, but only comment on one.

Candidates were expected to be able to analyze all three risk measures and provide a corresponding analysis of the best option.

To obtain full credit, a candidate needed to either graph all three risk measures and draw a conclusion based on all three graphs, or provide a detailed enough description and analysis of each risk measure that the graphs were not necessary.

Part b

Candidates generally scored well on this question, though several lost credit if they solely based their decision on either the cost of capital or net cost of reinsurance. To receive full credit, candidates needed to demonstrate the knowledge that both the cost of capital and cost of reinsurance need to be accounted for when determining which option is better.

QUESTION 27	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** C6: Describe the rationale for, methods for, and effect of managing insurance and financial risks.

SAMPLE ANSWERS

Part a: 1 point

Sample Answer 1

The biggest cost for insurers is the devaluing of the actual insurance product, the insurer's promise to pay claims. Since funds may not be there to pay claims the product is worth less. Customers will demand a discount for purchasing or shop elsewhere. This can lead to lower profitability & lost revenue & could start a vicious cycle.

Sample Answer 2

It can make it more difficult to raise capital efficiently. New shares will be at a discount. If borrowing, interest rates will be high. Even good assets can't be sold for the best price because we can't wait for the best offer.

Sample Answer 3

Market capital reactions to an insurer entering distress tend to be a multiple of the actual drop in book value that caused the distress.

Sample Answer 4

Agency problems exist because management (on behalf of shareholders) may be better off taking higher levels of risk during distress while policyholders are primary debtholders that would be hurt by risk.

Part b: 0.5 point

Sample Answer 1

Lack of access to capital markets (they have fewer choices for raising funds if they fall into distress).

Sample Answer 2

For mutual companies, policyholders are the owners and are more risk-averse than shareholders of public companies.

EXAMINERS' REPORT

Part a

Candidates scored well on this part. To obtain full credit, the candidate had to provide two valid consequences, and explain why each would occur to an insurance company in financial distress. Common errors included:

- Insufficient descriptions
- Providing two consequences that were essentially the same, and so only earning credit for one of them.

Part b

Candidates scored well on this part. Only a brief description of each reason was required for full credit. The most common error was to provide two reasons that were essentially the same, and so only earn credit for one of them.

QUESTION 28	
TOTAL POINT VALUE: 1	**LEARNING OBJECTIVE:** C7: Describe operational risk and demonstrate possible mitigation and quantification methodology. C8: Evaluate best practices in risk measurement, modeling, and management of various financial and non-financial risks faced by an entity.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

Operational risk is the risk of loss from failed or inadequate internal systems, processes, or people, or from external events. It includes legal risk but excludes strategic or reputational risk.

Strategic risk is risk of loss from making right or wrong strategic decisions.

Operational risk is risk of loss from failure in executing the company's business strategy and operations. Strategic risk is risk of loss from incorrectly selecting the wrong strategy to begin with.

Sample Answer 2

Operational risk is the risk of a failed execution while strategic risk is the risk of having a bad plan regardless of execution.

Part b: 0.5 point

Sample Answer 1

Industry risk – includes capital intensiveness, overcapacity, commoditization, deregulation, and cycle volatility. These are all significant risks for an insurer.

Competitor risk – Includes global rivals, gainers, and unique competitors. For an insurer, this includes aggressive or predatory pricing that drives market price levels down below adequate levels.

Sample Answer 2

Competitor risk, industry risk

Sample Answer 3

Stagnation → flat profits, declining volume
Industry → capital intensity, regulation

Sample Answer 4

Loss of reputation, expanding in a territory without underwriting expertise

EXAMINERS' REPORT

Candidates were expected to know the definitions of operational and strategic risks and were expected to be able to contrast them. For the second part of the question, candidates were expected to identify at least two types of strategic risk.

Candidates generally did very well. If a candidate lost any points for part a, it was related more to the definition of strategic risk than operational risk. Almost everyone was able to define operational risk correctly. For part b, some candidates listed operational risks when the question asked for strategic risks.

We note that while operational risk is clearly and consistently defined throughout the exam syllabus, the same is not true for strategic risk, which has multiple definitions across different papers. Any candidate response consistent with any of these definitions received credit.

Very few candidates left this question blank.

Part a

Candidates were expected to know the definitions of operational and strategic risks and how to contrast them.

Candidates who defined the two risks well without explicitly contrasting them earned full credit, as long as their definitions demonstrated competent knowledge of the two risk types. A candidate could also contrast the two risks with regards to a specific area and earn full credit this way.

Almost all candidates defined operational risks correctly. The candidates who lost points generally did not define strategic risk correctly or well enough.

Part b

Candidates were expected to identify at least two strategic risks. Candidates could simply list a strategic risk, for example brand risk or industry risk, to receive full credit. Candidates were not required to explain the risk in further detail, though many did. The most common error was to provide operational rather than strategic risks.

QUESTION 29	
TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE:** C7: Describe operational risk and demonstrate possible mitigation and quantification methodology. C8: Evaluate best practices in risk measurement, modeling, and management of various financial and non-financial risks faced by an entity.

SAMPLE ANSWERS

Part a: 2 points

Sample Answer 1

Currency risk: Company B is exposed to currency risk because all invested assets are in foreign currency. Company A does not have this risk.

Concentration risk: Company A has greater concentration risk than Company B because Company A only writes one line of business in one state, while Company B writes multiple lines in all states.

Catastrophe/Event risk: Company A has significant catastrophe risk because it writes a catastrophe prone coverage (homeowners) in a catastrophe prone state (Florida, hurricanes) and only has quota share reinsurance which does not significantly reduce extreme event losses relative to premium. Company B has less catastrophe risk because it has excess of loss reinsurance, which reduces extreme losses significantly relative to premium, and writes lines that are less prone to catastrophes (auto liability, general liability) and in all 50 states.

Liquidity risk: Company A has greater risk. It's negative outlook credit rating could lead to a downgrade causing cash calls and significant liquidity problems. Its exposure to catastrophe losses also poses liquidity risk from large cash calls following an event. Company B has less liquidity risk, does not have these potential threats than company A has.

Sample Answer 2

Concentration by industry: A only writes Homeowners but B writes auto liability and general liability. A may face more risk due to only writing one line of business.

Concentration by geography: A has more risk since they only write in Florida and are exposed to catastrophe losses from hurricanes. B is more diversified since they write in all 50 states.

Currency Risk: B has more risk for foreign currency since they only invest in foreign equities and bonds. A only has US equities so does not face as much currency risk.

Net Risk Retention: A uses quota share but since they only write in Florida, where hurricanes are common, they could face potentially high losses for many policies at once. Company B uses excess of loss, which reduces this tail type risk.

Part b: 0.5 point

Sample Answer 1:

1. A can reduce its underwriting risk by purchasing excess of loss insurance to protect it from catastrophes (hurricanes). 2. A can diversify its asset portfolio to invest in bonds (preferably highly rated ones) to reduce its market risk profile.

Sample Answer 2:

1. Can expand to states other than Florida 2. Purchase catastrophe reinsurance.

EXAMINERS' REPORT

Candidates generally scored very well, though responses to part b were stronger than to part a. Almost all candidates responded to this question, despite it being the last question of the exam.

Part a

Candidates were expected to be able to identify at least four types of risks that insurance companies are exposed to and then contrast the two given companies' risk profiles in the four mentioned risk areas.

The following were the most common ways in which candidates lost credit:

1. Not describing both companies' risk profile for the risks named (often just describing one company and not mentioning the other company at all)
2. Naming a risk but describing a different risk (for example, stating market risk and then stating that Company A's market risk was high because they only wrote in one state, which is underwriting risk, not market risk)
3. Naming downgrade risk as a risk and then stating that Company A had downgrade risk because they had a negative credit outlook without explaining exactly what a downgrade would do (lower company bond value or share value, cause policyholders to leave, etc.).
4. Only listing three risks instead of four.

Part b

Most candidates received full credit for part b, suggesting two ways for Company A to reduce its risk profile, though quite a few candidates did not provide a response to part b.

The most common error was to state that Company A should improve its credit rating outlook, without suggesting specific ways to do so, which was not a full enough response to earn full credit.