Exam 7

CASUALTY ACTUARIAL SOCIETY
AND THE
CANADIAN INSTITUTE OF ACTUARIES

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Exam 7

Estimation of Policy Liabilities, Insurance Company Valuation, and ERM

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4 HOURS

INSTRUCTIONS TO CANDIDATES

1. This 61.5 point examination consists of 28 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. For your Candidate ID number, four boxes are provided corresponding to one box for each digit in your Candidate ID number. If your Candidate ID number is fewer than 4 digits, begin in the first box and do not include leading zeroes. Your name, or any other identifying mark, must not appear.

   - Do not answer more than one question on a single sheet of paper. Write only on the front lined side of the paper – **DO NOT WRITE ON THE BACK OF THE PAPER**. Be careful to give the number of the question you are answering on each sheet. If your response cannot be confined to one page, please use additional sheets of paper as necessary. Clearly mark the question number on each page of the response in addition to using a label such as "Page 1 of 2" on the first sheet of paper and then "Page 2 of 2" on the second sheet of paper.

   - The answer should be concise and confined to the question as posed. When a specified number of items are requested, do not offer more items than requested. For example, if you are requested to provide three items, only the first three responses will be graded.

   - In order to receive full credit or to maximize partial credit on mathematical and computational questions, you must clearly outline your approach in either verbal or mathematical form, showing calculations where necessary. Also, you must clearly specify any additional assumptions you have made to answer the question.

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

CONTINUE TO NEXT PAGE OF INSTRUCTIONS
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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.

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

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

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

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

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

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

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

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

10. The exam survey is available on the CAS Web Site in the "Admissions/Exams" section. Please submit your survey by May 23, 2016.

END OF INSTRUCTIONS

1. (3.5 points)

Given the following information:

Cumulative Loss Payments

Accident Year	12 Months	24 Months	36 Months
2013	1,500	2,700	3,450
2014	1,600	2,740	
2015	1,700		

- Exposures and premium are constant across all accident years.
- There is no development beyond 36 months.

a. (2 points)

Calculate the total reserve indication as of December 31, 2015 using loss-ratio based payout factors and the Benktander method.

b. (0.75 point)

Calculate the fifth-iteration Benktander method reserve indication for accident year 2015.

c. (0.75 point)

Assuming $Var[U_i] = Var[U_i^{BC}]$, use Hürlimann's method for optimal credibility and minimum variance to calculate the reserve indication for accident year 2015.

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2. (3.25 points)

Given the following information ($000,000):

Accident Year	Cumulative Reported Loss @ 24 Months	Ultimate Loss
2011	36	75
2012	40	71
2013	35	64
2014	25	

a. (1.25 points)

Using the least squares method, estimate ultimate loss for accident year 2014.

b. (0.5 point)

For each of the following scenarios, briefly describe a potential problem with the output of the least-squares method:

i. The slope parameter is negative.
ii. The intercept parameter is negative.

c. (1.5 points)

Due to a regulatory change, the following is anticipated:

- No change in the reporting pattern.
- Standard deviation of reported loss as of 24 months will be 10% of estimated ultimate loss.
- Expected ultimate loss for accident year 2014 will decrease 20%.
- Standard deviation of accident year 2014 ultimate loss is expected to be $6,000,000.

Using the Bayesian credibility method, estimate the revised ultimate loss for accident year 2014.

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3. (2.5 points)

Given the following information as of December 31, 2015:

Accident Year	On-level Premiums	Cumulative Paid Loss	Fitted Paid Emergence Pattern
2012	$500,000	$210,000	65%
2013	600,000	150,000	40%
2014	550,000	70,000	20%
2015	650,000	30,000	10%

Cape Cod Method

- Parameter standard deviation: 250,000
- Process variance/mean scale parameter (σ^2): 4,000

LDF Method

- Parameter standard deviation: 325,000
- Process variance/mean scale parameter (σ^2): 4,500

a. (1.25 points)

Calculate the total standard deviation of the total loss reserve indication resulting from the Cape Cod method.

b. (0.75 point)

Calculate the total standard deviation of the total loss reserve indication resulting from the LDF method.

c. (0.5 point)

Explain why σ^2 for the LDF method is higher than σ^2 for the Cape Cod method.

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4. (1.75 points)

Given the following information for an insurer's book of business as of December 31, 2015:

Accident Year	On-Level Premium ($000)	Paid Losses ($000)
2012	800	480
2013	1,000	530
2014	1,500	640
2015	1,250	290

- The expected loss payment pattern for the insurance company was approximated by the following function, where G is the cumulative proportion of ultimate losses paid and x represents the average age (in months) since accident occurrence:

$$G(x) = \frac{x^{1.1}}{x^{1.1} + 8.0^{1.1}}$$

- The expected loss ratio (ELR) is 62.5% for this book.

a. (0.75 point)

Use the Cape Cod method to calculate the expected unpaid losses for accident year 2013.

b. (1 point)

Evaluate the appropriateness of using the Cape Cod method with a constant ELR for this book of business.

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5. (2.25 points)

Given the following information:

Age-to-age development factors

Accident Year	12-24 Months	24-36 Months	36-48 Months	48-60 Months	60-72 Months
2008	1.324	1.127	1.065	1.025	1.012
2009	1.313	1.127	1.058	1.027	
2010	1.344	1.135	1.070		
2011	1.340	1.134			
2012	1.344				

- Var[Z] = 1.125, where Z is the calendar year effect test statistic developed by Mack.
- z-value for the 95th percentile of the normal distribution: 1.645

a. (2 points)

Using the procedure shown by Mack, test the null hypothesis that the triangle does not exhibit calendar year effects at the 90% confidence level.

b. (0.25 point)

Identify one internal company action that can cause calendar year effects in a loss development triangle.

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6. (3.5 points)

Given the following information:

Age-to-Age Development Factors

Accident Year	12-24 Months	24-36 Months	36-48 Months	48-60 Months
2011	1.600	1.375	1.091	1.125
2012	5.000	1.100	2.000	
2013	2.833	1.588		
2014	2.091			

- Assume that $T = r\,[(n-2)\,/\,(1-r^2)]^{1/2}$
- The following table displays the t-statistic for 0.9 at various degrees of freedom:

Degrees of Freedom	1	2	3
t-statistic	6.314	2.920	2.354

a. (2 points)

Using Venter's correlation test, determine whether the correlation between the pair of development factor columns (12-24 Months) and (24-36 Months) is significant at the 10% level.

b. (1 point)

Calculate Spearman's rank correlation coefficient for the triangle as a whole.

c. (0.5 point)

Briefly describe two reasons why it may be more appropriate to consider the correlation of a loss development triangle as a whole instead of correlations between pairs of columns.

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7. (1.75 points)

Given the following information:

Cumulative Reported Losses ($000)

Accident Year	As of 24 Months	As of 36 Months
2009	3,000	5,000
2010	5,000	8,000
2011	2,500	9,000
2012	3,200	6,000
2013	3,800	7,000
2014	2,500	

a. (1.25 points)

Create a scatter plot of the weighted residuals for reported losses as of 36 months against reported losses as of 24 months following Mack's methodology.

b. (0.5 point)

Identify the chain-ladder method assumption needed for least-squares optimality that can be tested by reviewing the scatter plot created in part a. above and briefly explain whether this assumption has been violated.

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8. (1.25 points)

Two actuaries estimate the exponential claim size model parameters at the cost level of exposure year 5 and at the same basic limit via Sahasrabuddhe's approach to claim size modeling as follows:

	Development Interval				
Actuary	1	2	3	4	5
A	50,000	120,000	165,000	195,000	205,000
B	25,000	65,000	95,000	115,000	120,000

All other assumptions made by the actuaries are the same.

Both actuaries use their claim size model to estimate cumulative development factors adjusted for trend and limit changes. They then compare these factors to the unadjusted cumulative development factors calculated using weighted-average link ratios that use all available development periods.

a. (0.75 point)

Identify which actuary's modeled development factors deviate further from the unadjusted development factors and explain the effect of different claim size parameters on modeled development patterns that causes such a result.

b. (0.5 point)

Briefly describe two other modeling choices that could have created larger differences between the modeled factors and the unadjusted factors, assuming there had been differences in the actuaries' other assumptions.

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9. (2.25 points)

An insurer has written a book of workers compensation business for 20 years with a per-occurrence deductible of $250,000.

Given the following insurer and industry information:

Hazard Group	Insurer Premium Distribution	Industry Unlimited Expected Loss Ratio	Industry Excess Ratio at $250,000
1	50%	45%	0.05
2	30%	50%	0.10
3	10%	50%	0.20
4	10%	60%	0.40

Given the following information for the insurer:

- All 2014 claims have been reported by December 31, 2015
- 2014 earned premium is $50,000,000
- 2014 reported insurer-retained losses as of December 31, 2015 are $2,500,000

Unlimited severity at ultimate	$5,000
Unlimited severity at 24 months	3,200
Deductible severity at ultimate	2,000
Deductible severity at 24 months	1,500

a. (0.5 point)

Estimate the 2014 ultimate insurer-retained losses, incorporating the given industry information.

b. (1.25 points)

Estimate the 2014 ultimate insurer-retained losses using only the insurer's information.

c. (0.5 point)

Provide one reason for and one reason against selecting the estimate calculated in part a. above as opposed to the estimate calculated in part b. above.

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10. (3 points)

a. (0.5 point)

Define external systemic risk and internal systemic risk.

b. (1 point)

Identify and briefly describe two types of external systemic risk.

c. (1 point)

Identify and briefly describe two types of internal systemic risk.

d. (0.5 point)

Describe how the choice of valuation classes within a claims portfolio can affect internal systemic risk.

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11. (2.5 points)

An actuary is building a stochastic chain ladder model and is considering the following distributions:

- Over-Dispersed Poisson
- Over-Dispersed Negative Binomial
- Normal

Given the following information:

- Actual accident year 2015 losses at 12 months: $50,000
- Estimated chain-ladder accident year 2015 losses at 24 months: $75,000

a. (1.5 point)

For each of the following distributions, calculate the variance of the accident year 2015 losses at 24 months.

i. Over-dispersed Poisson model with $\varphi = 1.5$.
ii. Over-dispersed negative binomial model with $\varphi = 1.25$.
iii. Normally distributed model with $\varphi = 1.75$.

b. (0.5 point)

The actuary wants to use a model where the connection to the chain ladder method is immediately apparent. Identify and briefly explain which of the three models under consideration would achieve this.

c. (0.5 point)

The loss development triangle being used has a column of incremental values with a negative sum. The actuary wants to use a model that does not require adjustments to the data. Identify and briefly explain which of the three models under consideration would achieve this.

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12. (1.75 points)

a. (1 point)

When there are negative incremental values in loss development data, the log-link function used in the GLM framework will fail to yield values usable to parameterize the model. Describe two modifications to the log-link function that address this issue.

b. (0.75 point)

Given the following cumulative development triangle of reported losses to be used in a GLM bootstrapping model:

Accident Year	12 Months	24 Months	36 Months	48 Months
2011	1,500	1,300	1,200	1,250
2012	2,000	1,500	1,750	
2013	1,750	2,000		
2014	2,200			

Explain which of the two methods identified in part a. above is the more appropriate method to use on this data set.

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13. (1.5 points)

An actuary is reviewing residual plots from an over-dispersed Poisson bootstrapping model. The actuary chooses to review a plot of the residuals vs. development periods.

a. (0.5 point)

Identify two other residual plots the actuary might choose to review.

b. (0.5 point)

Briefly describe two features of residual plots that would suggest a need for the actuary to adjust the model.

c. (0.5 point)

In reviewing the plot of residuals vs. development periods, the actuary notices that the residuals appear to have larger absolute values at lower maturities. The actuary argues this is to be expected, because the incremental values are much larger in the earlier development periods and hence these incremental values should have a higher variance.

Assess the validity of the actuary's reasoning.

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14. (2.75 points)

Given the following output from a generalized linear model fitted to a triangle of loss development data:

Standardized Pearson Residuals

Accident Year	12 Months	24 Months	36 Months	48 Months	60 Months	72 Months
2010	1.68	2.65	-4.70	-2.78	3.37	0.00
2011	7.74	-1.34	-7.33	-1.91	-3.61	
2012	5.72	1.94	-6.91	4.98		
2013	-1.22	0.12	-1.94			
2014	1.67	-1.87				
2015	0.00					

Standard Deviations of Standardized Pearson Residuals

Accident Year	Standard Deviation	Accident Year Range	Standard Deviation
2010	3.571	2010 to 2011	4.463
2011	5.563	2012 to 2013	4.345
2012	5.797	2014 to 2015	2.503
2013	1.045	2010 to 2012	4.741
2014	2.503	2013 to 2015	1.537

Fitted Cumulative Losses

Accident Year	12 Months	24 Months
2012	3,500	7,612
2013	4,210	8,749
2014	5,400	10,654

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(14 continued)

An actuary reviewing the output notices heteroscedasticity in the residuals. The actuary decides to adjust for this by calculating variance parameters before running the sampling algorithm.

Given the following residual index values from one iteration of the sampling algorithm:

Accident Year	Sample Residual Index (row, column)
2012	5, 1
2013	1, 3
2014	4, 3

a. (2.25 points)

Calculate the actuary's sampled incremental losses for accident years 2012-2014 between 12 and 24 months for the sample under consideration.

b. (0.5 point)

Explain why heteroscedastic residuals might cause issues when using a bootstrapping technique to estimate variance of unpaid claim estimates.

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15. (2.25 points)

An actuary is retrospectively testing the general applicability of the Mack stochastic reserving model for Products Liability using incurred loss triangles from 20 insurance companies.

The following procedure was performed:

- The Mack model was used to fit each insurer's incurred loss triangle as of 10 years before the latest available annual data.
- A lognormal distribution was derived for each triangle by matching the mean and standard deviation from the Mack model results.
- Percentiles for each insurer's actual 10-year loss emergence were calculated assuming the lognormal distributions described above.

Given the following percentiles for each company's actual loss development within the distribution derived with the Mack model, in ascending order:

12	45	53	67
29	49	58	69
37	50	61	71
40	51	62	72
44	52	66	84

a. (1 point)

Determine whether the model is validated by applying the Kolmogorov-Smirnov test at the 5% confidence level, where the critical value is 30.4.

b. (0.5 point)

Identify two reasons why loss reserve models often do not accurately predict the distribution of outcomes.

c. (0.75 point)

Identify one shortcoming of the Mack model. Propose an alternative model and briefly explain a feature of the alternative model that addresses this shortcoming,

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16. (1.75 points)

Given the following reinsurance company data ($000) as of December 31, 2015:

Calendar-Accident Year	Earned Risk Pure Premium	Adjusted Premium	Aggregate Reported Loss	Reported Loss Development Factor to Ultimate
2012	20,500	21,000	9,000	1.250
2013	21,500	27,000	6,000	2.500
2014	22,800	25,000	4,000	5.000
2015	24,000	24,000	3,250	8.000
Total	88,800	97,000	22,250	n/a

- The selected credibility factor is 0.80.

a. (1 point)

Use the Stanard-Bühlmann method to estimate the IBNR for all years combined.

b. (0.75 point)

Use the credibility weighting of the Stanard-Bühlmann and chain ladder methods as presented by Patrik to estimate the IBNR for accident year 2014.

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17. (1.5 points)

Consider this statement:

Primary insurer loss reserving is more straightforward than reinsurance loss reserving because (1) claim report lags to reinsurers are generally longer, and (2) claims reporting patterns differ greatly by reinsurance line and type of contract.

a. (0.5 point)

Identify two other technical problems with reinsurance reserving that support the above statement.

b. (1 point)

Briefly describe two underlying causes of each technical problem identified in part a. above.

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18. (3 points)

Given the following information for a retrospectively rated book of business as of December 31, 2015:

Policy Effective Year	Policy Effective Quarter	Ultimate Loss	Losses Reported at Prior Retro Adjustment
2011	1	$92,500	$92,500
2011	2	57,000	57,000
2011	3	125,000	125,000
2011	4	80,000	78,000
2012	1	64,000	57,000
2012	2	37,500	30,000
2012	3	60,000	55,000
2012	4	65,000	60,000
2013	1	55,000	50,000
2013	2	40,000	33,000
2013	3	70,000	52,500
2013	4	60,000	45,000
2014	1	50,000	0
2014	2	40,000	0
2014	3	65,000	0
2014	4	45,000	0
2015	1	25,000	0
2015	2	20,000	0
2015	3	30,000	0
2015	4	5,000	0

Retro Adjustment Period	Selected PDLD Ratio	Percent Loss Emerged
First	1.75	78.5%
Second	0.70	10%
Third	0.55	7%
Fourth	0.45	4%
Subsequent	0.00	0.5%

Policy Period	Premiums Booked from Prior Adjustment	Premiums Booked as of December 31, 2015
2011	$450,000	$452,000
2012	335,000	337,000
2013	330,000	335,000
2014-2015	0	425,000

Calculate the premium asset as of December 31, 2015.

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19. (3 points)

Given the following financial projections for an insurer as of December 31, 2016 ($000,000):

	Calendar Year		
	2017	2018	2019
Beginning US GAAP equity	1,000	xxx	xxx
Projected Net Income	80	100	140
Minimum Capital to maintain AA Rating at year end	1,015	1,035	1,040
Minimum Capital required by governing regulator at year end	813	840	875
Minimum Capital to meet management's growth target at year end	1,017	1,015	1,035
Change in loss and expense reserves	100	-75	25
Net borrowing	12	0	15

- Risk-free rate: 2.0%
- Expected equity market risk premium: 6.0%
- Insurance company equity beta: 1.25

a. (0.5 point)

Determine the required equity return percentage based on the Capital Asset Pricing Model (CAPM).

b. (2.5 points)

Determine the value of this company as of January 1, 2017 based on the Free Cash Flow to Equity (FCFE) method.

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20. (2.75 points)

Given the following information for a property & casualty insurer:

2015 Earnings	$700,000,000
Book value at December 31, 2015	$6,000,000,000

Also given the following information for a sample of other insurers:

	Capitalization ($ billions)	Price to Earnings	Price to Book Value
Life Ins Co 1	20	16.2	1.8
P&C Ins Co 1	15	12.9	1.4
P&C Ins Co 2	9	11.7	1.5
Health Ins Co 1	6	13.4	1.5
P&C Ins Co 3	3	11.1	1.2
P&C Ins Co 4	1	19.0	1.9

a. (1 point)

Estimate the firm's value by incorporating both the price to earnings and price to book value multiples.

b. (0.5 point)

Describe a risk of using market multiples to value a company.

c. (0.5 point)

Describe a way to counter the risk identified in part b. above while still using market multiples.

d. (0.75 point)

Transaction multiples offer an alternative method of valuation to market multiples. Briefly describe one advantage and two weaknesses of using transaction multiples.

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21. (2.5 points)

An insurance company has developed an Enterprise Risk Management (ERM) program with the following characteristics:

i. The process will be monitored on a regular basis.

ii. The ERM model only incorporates insurance hazard risk and financial risk.

iii. The company has excluded motorcycle liability from the ERM model because it is a short-tailed line of business, represents a small portion of the book, and is in run-off.

iv. The model only considers adverse scenarios, because if the outcomes turn out better than expected, there is no risk to the insurance company.

v. The insurance company writes both commercial lines and personal lines. Since the underwriting and pricing of these risks are handled by separate departments, there are two completely independent ERM models that exist for commercial lines and personal lines.

Describe whether each characteristic above is a strength or a weakness of the ERM program.

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22. (1.5 points)

An insurance company has decided to manage the underwriting cycle by reducing market share when pricing is soft and expanding market share when pricing is hard.

a. (1 point)

Outline and justify an asset management strategy that could reduce the company's earnings volatility.

b. (0.5 point)

Discuss a risk that would increase if this strategy were implemented.

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23. (2.25 points)

a. (1 point)

Describe two drawbacks of using default avoidance as the reference point for setting capital requirements in ERM.

b. (0.5 point)

Briefly describe two other meaningful reference points for setting capital requirements.

c. (0.75 point)

Using one of the reference points identified in part b. above, develop a minimum capital requirement that relates a maximum capital loss tolerance to a TV@R measurement.

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24. (2 points)

An insurance company wants to allocate capital to a newly purchased portfolio based on the portfolio's aggregate loss distribution.

The portfolio contains the following two lines of business:

- Commercial Property subject to both earthquake and hurricane risks
- Excess Casualty with a large policy limit

The following risk measures are under consideration:

- Standard deviation
- TV@R
- TV@R with transformed probabilities

a. (1.5 points)

Evaluate the appropriateness of these three risk measures for this portfolio and recommend which measure the company should adopt.

b. (0.5 point)

Identify one additional risk measure that would be suitable for this capital allocation and briefly describe its appropriateness for this portfolio.

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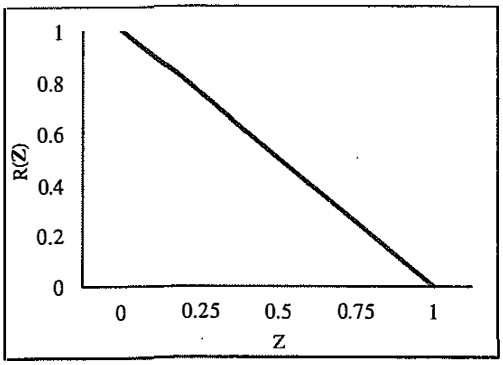
25. (1.25 points)

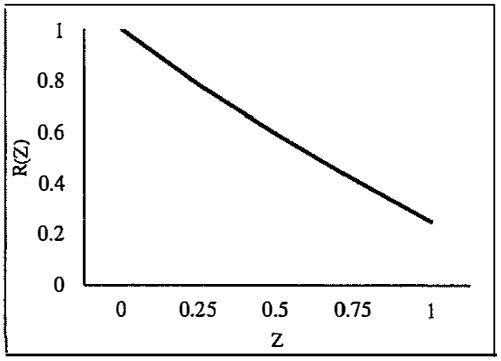
An insurer writes commercial property and workers compensation insurance in the same geographical area. The insurer is considering two copulas to model the joint distribution of these two lines of business.

Below is a plot of the right-tail concentration function for each copula:

Function for Copula 1



Function for Copula 2



a. (0.75 point)

Discuss which function is more appropriate if the insurer is writing business in an area with high exposure to earthquakes.

b. (0.5 point)

Briefly explain why graphs of right-tail concentration functions can often be misleading and recommend a solution to this problem.

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26. (1 point)

An insurance company with a substantial book of long-tailed business is using a plan loss ratio model to determine premium growth targets. The plan loss ratio is also used in the reserve review process as the expected loss ratio.

a. (0.5 point)

Identify two potential negative consequences of an optimistic plan loss ratio to the company's financial results.

b. (0.5 point)

Explain why it is difficult to separate operational risk from underwriting risk when explaining the impact of an optimistic plan loss ratio on the company's financial results in retrospect.

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27. (1.25 points)

An insurance company writes predominantly long-tailed lines of business in a highly competitive environment. The company's incentive plan is structured around achieving both top line growth and target calendar year combined ratios. Recently the company has seen a number of accounts go to competitors for lower rates and increased coverage.

a. (0.25 point)

State a goal of agency theory.

b. (0.5 point)

In the context of agency theory, discuss the problems this company may be facing.

c. (0.5 point)

Briefly describe two actions the company could take to implement effective underwriting cycle management.

CONTINUED ON NEXT PAGE

28. (2 points)

a. (0.75 point)

Identify and describe one "soft" approach to modeling the underwriting cycle.

b. (0.75 point)

Identify and describe one technical approach to modeling the underwriting cycle.

c. (0.5 point)

Briefly describe one feature that econometric modeling of the underwriting cycle has in common with "soft" approaches and one feature that it has in common with technical models.

END OF EXAMINATION

Exam 7

Estimation of Policy Liabilities, Insurance Company Valuation, and Enterprise Risk Management

POINT VALUE OF QUESTIONS

QUESTION	VALUE OF QUESTON	SUB-PART OF QUESTION (a)	(b)	(c)	(d)	(e)	(f)	(g)
1	3.50	2.00	0.75	0.75				
2	3.25	1.25	0.50	1.50				
3	2.50	1.25	0.75	0.50				
4	1.75	0.75	1.00					
5	2.25	2.00	0.25					
6	3.50	2.00	1.00	0.50				
7	1.75	1.25	0.50					
8	1.25	0.75	0.50					
9	2.25	0.50	1.25	0.50				
10	3.00	0.50	1.00	1.00	0.50			
11	2.50	1.50	0.50	0.50				
12	1.75	1.00	0.75					
13	1.50	0.50	0.50	0.50				
14	2.75	2.25	0.50					
15	2.25	1.00	0.50	0.75				
16	1.75	1.00	0.75					
17	1.50	0.50	1.00					
18	3.00	3.00						
19	3.00	0.50	2.50					
20	2.75	1.00	0.50	0.50	0.75			
21	2.50	2.50						
22	1.50	1.00	0.50					
23	2.25	1.00	0.50	0.75				
24	2.00	1.50	0.50					
25	1.25	0.75	0.50					
26	1.00	0.50	0.50					
27	1.25	0.25	0.50	0.50				
28	2.00	0.75	0.75	0.50				
TOTAL	61.50							

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EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S 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.
- Candidates should justify all selections when prompted to do so. For example, if the candidate selects an all-year average and the question prompts a justification of all selections, a brief explanation should be provided for the reasoning behind this selection. Candidates should note that a restatement of a numerical selection in words is not a justification.
- Incorrect responses in one item part did not preclude candidates from receiving credit for correct work on subsequent item parts that depended upon that response.
- Candidates should pay attention to the wording of each exam item. They must look for key words such as "briefly" or "fully". We refer candidates to the December 2009 *Future Fellows* article "The Importance of Adverbs" for additional information on this topic. For example, some candidates provided lengthy responses to a "briefly describe" question, which does not earn further credit, but instead merely takes up valuable exam time.
- Candidates should be cautious of relying solely on study manuals; many candidates lost credit for failing to provide basic insights and content contained in the syllabus readings.
- Candidates should note that the sample answers provided in the examiner's report are not an exhaustive representation of all responses given credit during grading, but rather the most common correct responses.
- In cases where a given number of items were requested (e.g., "three reasons" or "two scenarios"), the examiner's report often provides more sample answers than the requested number. The additional responses are provided for educational value, and would not have resulted in any additional credit for candidates who provided more than the requested number of responses. Candidates are reminded that, per the instructions to the exam, when a specific number of items is requested, only the items adding up to that number will be graded (i.e., if two items are requested and three are provided, only the first two are graded).

EXAM STATISTICS:

- Number of Candidates: 603
- Available Points: 61.50
- Passing Score: 45.25
- Number of Passing Candidates: 226
- Raw Pass Ratio: 37.5%
- Effective Pass Ratio: 39.0%

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 1	
TOTAL POINT VALUE: 3.5	**LEARNING OBJECTIVE:** A1: Calculate unpaid claim estimates using credibility models.
SAMPLE ANSWERS	
Part a: 2 points	

Sample Answer 1

Assume premium = 5,000 for each accident year. Other premium amounts may be assumed

M_1 = [(1,500 + 1,600 + 1,700)/3 × 5,000] = 0.32
M_2 = [(1,200 + 1,140)/2 × 5,000] = 0.234
M_3 = 750/5,000 = .15
Expected loss ratio = 0.704. U^0 = .704 x 5,000 = 3,520
P_1 = .32/.704 = .455; Q_1 = 1 - .455 = .545
P_2 = (.32 + .234)/.704 = .787; Q_1 = 1 - .787 = .213

2014_{ind} = 2,740/.787 x .213 = 742
2015_{ind} = 1,700/.455 x .545 = 2,036

2014_{coll} = 3,520 × .213 = 750
2015_{coll} = 3,520 × .545 = 1,918

2014_{bt} = 742 × .787 + 750 × .213 = 743
2015_{bt} = 2,036 × .455 + 1,918 × .545 = 1,972

Total reserve = 743 + 1,972 = 2,715

Sample Answer 2:

Avg. Paid:
0-12 months = (1,500 + 1,600 + 1,700)/3 = 1,600
12-24 months = (1,200 + 1,140)/2 = 1,170
24-36 months = 750

U^0 = 1,600 + 1,170 + 750 = 3,520

P_1 = 1,600/3,520 = .455; Q_1 = 1 - .455 = .545
P_2 = (1,600 + 1,170)/3,520 = .787; Q_1 = 1 - .787 = .213

1st iteration ultimate losses

2014 = 3,520 × .213 = 750; 750 + 2740 = 3,490
2015 = 3,520 × .545 = 1,918; 1918 + 1,700 = 3,618

2nd iteration ultimate losses

2014 = 3,490 × .213 = 743; 743 + 2740 = 3,483

2015 = 3,618 × .545 = 1,972; 1972 + 1,700 = 3,672

Total estimated Benktander outstanding losses as of December 31, 2015 =

3,483 + 3,672 – 2740 – 1700 = 2,715

Part b: 0.75 point

Sample Answer 1

Expected Cost Reserves for AY 2015 2015_{Ec}= (5,000) × 70.4% - 1,700 = 1,820

Fifth Iteration Benktander Reserve = $2015_{ind} \times (1- q^5) + 2015_{Ec} \times q^5$
= $2{,}036 \times (1-0.545^5) + 1{,}820 \times 0.545^5$
= 2,025.6

Sample Answer 2

2nd iteration ultimate losses from part A
2015 = 3,618 ×0 .545 = 1,918; 1,918 + 1,700 = 3,672

3rd iteration ultimate losses from part A
2015 = 3,672 × 0.545 = 2,001; 2,001 + 1,700 = 3,701

4th iteration ultimate losses from part A
2015 = 3,701 × 0.545 = 2,017; 2,017 + 1,700 = 3,717

5th iteration ultimate losses from part A
2015 = 3,717 × 0.545 = 2,026; 2,026 + 1,700 = 3,726

Reserve = 5th iteration Ultimate minus paid = 3,726 – 1700 = 2,726

Part c: 0.75 point

Sample Answer 1

$Z = P_1 / (P_1 + \sqrt{P_1}) = 0.455 / (0.455 + \sqrt{0.455}) = 0.403$
Reserve = $Z \times 2015_{ind} + (1 - Z) \times 2015_{coll}$ = 0.403 × 2,036 + 0.597 × 1,918 = 1,966

Sample Answer 2

$Z = P_1 / (P_1 + \sqrt{P_1}) = 0.455 / (0.455 + \sqrt{0.455}) = 0.403$
Estimated Ultimate = 0.403 × 3,736 + 0.597 × 3,618 = 3,666
Reserve = Estimated Ultimate minus Paid = 3,666 – 1,700 = 1,966

EXAMINER'S REPORT

Candidates were expected to know how to produce loss ratio based payout factors and apply these factors in conjunction with the Benktander method. Many candidates lost credit for being unable to produce loss ratio based payout factors as outlined in Hurlimann. In addition, many candidates struggled to produce the correct *a priori* estimate.

Many candidates also lost credit for assuming the Benktander method was the first iteration of the calculation rather than the second.

These items notwithstanding, most candidates performed reasonably well overall.
Part a
Candidates were expected to know how to produce loss ratio based payout factors and apply those factors in conjunction with the Benktander method. Many candidates struggled to produce loss ratio based payout factors and instead used a weighted average. Candidates also struggled to produce the appropriate *a priori* loss estimate. Many assumed a value of 3,450 since the oldest year was fully developed. However, this fails to recognize that payments for more recent years are emerging higher than corresponding payments for 2013. Once the payout factors and *a priori* estimate were derived, most candidates were able to compute the outstanding losses using the Benktander method.
Part b
Many candidates failed to understand that the Benktander method produces the second iteration reserve – not the first. Because of this, many candidates calculated the sixth iteration reserve and received partial credit.
Part c
The majority of candidates performed very well, receiving full credit.

QUESTION 2	
TOTAL POINT VALUE: 3.25	**LEARNING OBJECTIVE:** A1: Calculate unpaid claim estimates using credibility models.

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

$$\bar{X} = \frac{36 + 40 + 35}{3} = 37$$

$$\bar{Y} = \frac{75 + 71 + 64}{3} = 70$$

$$\overline{XY} = \frac{36 * 75 + 40 \times 71 + 35 \times 64}{3} = 2593.33$$

$$\overline{X^2} = \frac{36^2 + 40^2 + 35^2}{3} = 1373.67$$

$$b = \frac{\overline{XY} - \bar{X}\bar{Y}}{\overline{X^2} - \bar{X}^2} = 0.713$$

$$a = \bar{Y} - b \times \bar{X} = 43.62$$

$$2014 \text{ Ultimate Loss} = a + b \times 25 = 61.45$$

Sample Answer 2

r = 0.33

$\sigma_X = 2.16$, $\sigma_Y = 4.55$

$$a = \frac{r \times \sigma_Y}{\sigma_X} = 0.7$$

$$b = \bar{Y} - a \times \bar{X} = 43$$

$$U_{2014} = 25 \times 0.7 + 43 = 61$$

Part b: 0.5 point

Sample Answer 1

i) If b < 0, then y decreases as x increases.
ii) If a < 0, then y is negative for small values of x.

Sample Answer 2

i) If b is negative, then ultimate loss (Y) decreases when reported loss (x) increases.
ii) If a is negative, then ultimate loss (Y) is negative when reported loss (x) is zero.

Sample Answer 3

i) Ult loss might be negative when intercept is small/reported is large.
ii) Ult loss might be negative when reported loss is small/slope is small.

Sample Answer 4

i) Negative slope suggests negative development.
ii) Negative intercept suggests when there have been no reported losses, the ultimate is negative.

Part c: 1.5 point

Sample Answer 1

$$\mathrm{L(x)} = Z \times \frac{X}{d} + (1 - Z)E(y)$$

$$E\ (y) = (1 - \ .2) \times \frac{75 + 71 + 64}{3} = 56$$

$$X = 25$$

$$d = \frac{36 + 40 + 35}{75 + 71 + 64} = \ .52857$$

$$Z = \frac{VHM}{VHM + EVPV} = \ \frac{10.05}{10.05 + 31.72} = .2407$$

$$VHM = E^2\left(\frac{X}{Y}\right)Var(Y) = (.52857)^2(6)^2 = 10.05796$$

$$EVPV = Var\left(\frac{X}{Y}\right)[Var(Y) + E^2(Y)] = .1^2(6^2 + 56^2) = 31.72$$

$$\mathrm{L(x)} = (.2407) \times \frac{25}{.52857} + (1 - .2407)(56) = 53.905\ \mathrm{M}$$

Sample Answer 2

$$\sigma_d = 0.1$$

$$\mathrm{Y} = 0.8\ \times\ 70 = 56$$

$$\sigma_Y = 6$$

$$\mathrm{d} = \frac{37}{70} = 0.5286$$

$$VHM = \sigma_Y^2 d^2 = 6^2(0.5286)^2 = 10.058$$

$$EVPV = \sigma_d^2[\sigma_Y^2 + Y^2] = \ 0.1^2(6^2 + \ 56^2) = 31.72$$

$$Z = \frac{VHM}{VHM + EVPV} = \frac{10.058}{10.058 + 31.72} = .2407$$

$$\mathrm{L} = .2407\left(\frac{25}{.5286}\right) + (1 - .2407)(56) = 53.904$$

EXAMINER'S REPORT

Part a

- In general, candidates performed very well on this subpart.
- A variety of different answers were accepted for *a*, *b*, and 2014 ultimate loss, due to rounding differences in the calculations of X-Bar, Y-Bar, etc.
- The most common mistakes included minor calculation errors.
- Numerous candidates performed the least squares regression using their calculators and used the output to calculate the estimated ultimate loss for 2014. This was acceptable, if performed correctly. However, if no work was shown and the ultimate value was calculated incorrectly, only minimal partial credit was awarded.
- It was not necessary to indicate that the dollar amounts were in millions.

Part b

Candidates were expected to identify potential issues with the least squares development method when either the estimated slope or intercept parameters are negative. In general, most candidates performed very well on this question. Candidates that received full credit made a clear connection between the negative parameter estimate and possibly inappropriate results. Conversely, simply stating that a "negative intercept parameter could lead to negative ultimate loss" did not receive credit because there was no explanation of the scenarios when the ultimate loss would be negative.

Candidates were not required to state a solution to either potential problem. No credit was awarded or deducted for including possible solutions to the stated problems. If candidates only included potential solutions but did not explicitly address why the negative parameters might be inappropriate, they received no credit.

Candidates also lost credit when they did not clearly differentiate between reported and ultimate losses. Stating that "losses are decreasing over time" did not receive full credit because it is not clear whether the reported or ultimate losses are decreasing over time.

Part c

In general, candidates performed well on this question.

- By far, the most common mistake that candidates made was to calculate the revised E(*y*) based on their answers to part (a). A common incorrect answer was E(*y*) = 0.8 × 61.45 = 49.16. Using the answer from part (a) is not correct as this an estimate of the *2014 ultimate loss* and not the *total expected ultimate loss, E(y)*.
- Candidates generally calculated the value of *d* correctly. A common mistake was dividing 25 by the answer from part (a) to get *d* = 25 / 61.45 = 0.407.

- Other less common mistakes included:
  - Incorrect formulas for VHM and EVPV, including switching the formulas.
  - Not consistently using the values calculated for E(y) and/or d when calculating a revised estimate of ultimate loss for accident year 2014.
  - Using the formula $Z = bd$ to solve for Z, but using the value of b calculated in part (a). This is not correct, since the value of b changes when the expected ultimate loss changes in part (c).
  - Miscellaneous computational errors.

QUESTION 3	
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.

SAMPLE ANSWERS

Part a: 1.25 points

Sample Answer 1

On lvl prem × emergence

Used up premium		CC Reserve = prem × ELR × (1- emergence)
2012 500K × .65 =	325,000	500,000 x .622 (1 -. 65) = 108,850
2013	240,000	223,920
2014	110,000	273,650
2015	65,000	363,570
total	740,000	Total = 970,320

$$ELR = \frac{210 + 150 + 70 + 30}{740}$$
$$ELR = .622$$

$$process\ std\ dev = \sqrt{4{,}000 \times 970{,}320} = 62{,}300$$
$$total\ std\ dev = \sqrt{62{,}300^2 + 250{,}000^2} = 257{,}646$$

Sample Answer 2

CC ELR = ∑ rptd Loss / ∑ Adj. EP × % rptd = [460,000 / (500,000(.65) + 600,000(.4) + 550,000(.2) + 650,000(.1)] = 460,000 / 740,000 = .6216

CC Res = Adj. EP × ELR × % unrptd = 500,000(.6216)(1-.65) + 600,000(.6216)(1-.4) + 550,000(.6216)(1-.2) + 650,000(.6216)(1-.1) = 969,696

Process Variance = σ^{2R} = 4,000(969,696) = 3,878,784,000
Total Variance = Process Var + Parameter Var = 3,878,784,000 + $250{,}000^2$ = 6.6378×10^{10}
Total Stdev = $\sqrt{6.6378 \times 10^{10}}$ = 257,641

Part b: 0.75 point

Sample Answer 1

$$LDF\ reserve = \frac{paid\ loss}{emergence} - pd\ loss$$

2012 210,000/.65 – 210,000 =	113,077
2013	225,000
2014	280,000
2015	270,000
total	888,077

$$process\ std\ dev = \sqrt{4{,}500(888{,}077)} = 63{,}217$$

$$total\ std\ dev = \sqrt{62{,}217^2 + 325{,}000^2} = 331{,}091$$

Sample Answer 2

LDF Res = Ck(CDF-1), CDF = 1 / % unpaid

LDF Res = 210,000(1.538-1) + 150,000(2.5-1) + 70,000(5-1) + 30,000(10-1) = 888,077

Process Variance = σ^{2R} = 4,500(888,077) = 3,996,346,154

Total Variance = Process Var + Parameter Var = 3,996,346,154 + $325{,}000^2$ = 1.09×10^{11}

Total Stdev = $\sqrt{1.09 \times 10^{11}}$ = 331,091

Part c: 0.5 point

Sample Answer 1

σ^2 higher for LDF as more parameters in LDF method

& σ^2 calc divides by n-p (# data pts in Δ - # parameters)

Sample Answer 2

The σ^2 for the LDF method is likely higher than for the Cape Cod method because we need to fit fewer parameters for the Cape Cod method (1 parameter for the ELR and 1 each for ω and θ) -> 3 parameters. Whereas the LDF method requires a parameter for every AY (4 + ω and θ) -> 6 parameters. This would lead to overfitting. Can also be seen in the formula for $\sigma^2 = [1 / n\text{-}p] \times \sum [(c - \mu)^2 / \mu]$ where c -> actual incremental value, μ -> fitted value. As p increases, the denominator becomes smaller -> σ^2 increases.

Sample Answer 3

$\sigma^2 = [1 / n\text{-}p] \times \sum r^2$

Since LDF uses more parameters than Cape Cod, it has a higher σ^2 since σ^2 penalizes for using too many parameters (by dividing by (n-p)).

Sample Answer 4

$\sigma^2 = [1 / n\text{-}p] \times \sum [(\text{actual} - \text{expected})^2 / \text{expected}]$

σ^2 is calculated with the number of parameters (p in the above) and since the LDF method uses more parameters than Cape Cod, the resulting σ^2 is larger.

EXAMINER'S REPORT

Overall, candidates demonstrated a strong understanding of the Cape Cod and LDF methods and how to use those methods to calculate reserves. Additionally, candidates demonstrated a strong understanding of the variance of a reserve estimate; particularly that it consists of two parts –

process and parameter variance.

Many candidates struggled with part c. Often, candidates responded to part c. as if the question were referring to total variance of the reserve estimate. Instead, the question was referring to the given Cape Cod and LDF σ^2 parameters.

Part a

The majority of candidates achieved full credit on this part or made minimal errors.

Candidates were expected to know:

- How to calculate the Cape Cod ELR (including used-up premium);
- The Cape Cod method for reserves;
- That process variance is the reserve estimate multiplied by σ^2; and
- That total variance (and hence total standard deviation) is the sum of both process and parameter variance.

Common errors for part a. were:

- Calculation errors for used-up premium;
- Using ultimates instead of reserves in the calculation of process variance;
- Calculating reserves as EP×ELR – paid to date;
- Errors resulting from mismatch in scale of figures in formulas (i.e., when converting figures to thousands); and
- Not squaring the parameter standard deviation provided when calculating the formula for total standard deviation.

Part b

The majority of candidates achieved full credit on this part or made minimal errors.

In addition to knowledge of total standard deviation demonstrated in part a., candidates were expected to know the LDF method formula for reserves.

Common errors for part b. were:

- Calculation errors for reserves;
- Using ultimates instead of reserves in the calculation of process variance;
- Errors resulting from mismatch in scale of figures in formulas (i.e., when converting figures to thousands); and
- Not squaring the parameter standard deviation provided when calculating the formula for total standard deviation.

Part c

In general, candidates did not perform well on part c.

To receive full credit, candidates were expected to know:

- That there are more parameters to estimate when using the LDF method compared to the Cape Cod method; and
- That the formula for approximating σ^2 penalizes over-parameterization by including (n-p) in the denominator (i.e., more parameters means a larger scaling factor, all else being equal).

Common errors for part c. were:

- Not describing the calculation for approximating σ^2, particularly the penalization for number of parameters;
- Many candidates mentioned that the Cape Cod method uses more information than the LDF method (e.g. premium). This reduces the total variance of the reserve estimate. However, the question refers to the σ^2 process variance/mean scale parameter.

QUESTION 4

TOTAL POINT VALUE: 1.75

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: 0.75 point

Sample Answer 1

Average Age (x) = 36 – 6 = 30
G(x) = 0.811
Premium × ELR for 2013 = $1,000,000 × 62.5% = $625,000
Unpaid Losses = $625,000 (1 - 0.811) = $118,125

Sample Answer 2

Assume no truncation needed.
2013 -> 30 months
$G(30) = 30^{1.1}/(30^{1.1}+8^{1.1}) = 81.06\%$
2013 expected unpaid = 1000 × 62.5% × (1-81.06%) = 118,375

Part b: 1 point

Sample Answer 1

AY	Used Up Premium	Loss	Loss / Unused Prem
2012	688.8	480	0.697
2013	811	530	0.654
2014	1063.5	640	0.602
2015	526.875	290	0.550

There is an obvious downward trend in the loss ratios emerged to date by AY (more recent AY show better loss performance). This implies that using an all year combined ratio may not be appropriate as it will overstate reserves for recent years and understate for older AY.

Sample Answer 2

Graph the expected paid total minus the paid to date vs time and expect to see consistency if they are a constant ELR.

AY	Avg Age	G(x)	Expected Paid	Paid	Difference
2012	42	0.861	430.5	480	-49.5
2013	30	0.811	506.875	530	-23.125
2014	18	0.709	664.69	640	24.69
2015	6	0.422	329.688	290	39.688

Expected Paid = On-level Prem × ELR × G(x)
Instead they are increasing with time so it is not appropriate.

EXAMINER'S REPORT
Part a
Candidates were expected to know how to calculate the expected unpaid losses for a single accident year using the Cape Cod method. To receive full credit, a candidate needed to calculate the correct average age of losses for 2013, then use that in the G(x) formula given, then to use that result in the Cape Cod formula to determine the unpaid losses. Common errors included using the average loss ratio for all four years rather than the loss ratio given and calculating a total for four years rather than just the 2013 year asked for. Many candidates chose to use the pattern truncation discussed in the reading. This was not necessary, and it neither earned nor lost credit.
Part b
Candidates were expected to know whether or not the Cape Cod method was appropriate when loss ratios were declining. To receive full credit, candidates had to calculate the *a priori* loss ratio (which includes a calculation of the used up premium). Candidates had to deduce that the declining pattern in the loss ratios indicated a bias that made the method inappropriate. The *a priori* loss ratio could be calculated more than one way for full credit. Common errors included not calculating any loss ratios and instead attempting to deduce the answer by looking at the given premiums (this provides enough evidence to trigger a look into the appropriateness of the Cape Cod method but not enough to make the determination), calculating the loss ratio incorrectly, and not stating a position on whether or not the method was appropriate.

QUESTION 5

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: 2 points

Sample Answer

	12-24	24-36	36-48	48-60	60-72
2008	*S*	*S*	*	*S*	*
2009	*S*	*S*	*S*	*L*	
2010	*L*	*L*	*L*		
2011	*	*L*			
2012	*L*				

Diagonal *j*	S_j	L_j	N_j= #S+#L	$m_j=\frac{n-1}{2}$	Z_j=min (#S, #L)	E(Z_j)	Var(Z_j)
2	2	0	2	0	0	0.50	0.25
3	1	1	2	0	1	0.50	0.25
4	2	1	3	1	1	0.75	0.1875
5	0	4	4	1	0	1.25	0.4375
				Total	2	3.00	1.125

$$E(Z_j) = \frac{n}{2} - \left(\binom{n-1}{m}\frac{n}{2^n}\right)$$

$$Var(Z_j) = \frac{n(n-1)}{4} - \left(\binom{n-1}{m}\frac{n(n-1)}{2^n}\right) + E(Z_j) - E(Z_j)^2$$

Range of Null [3-1.645(1.125$^{.5}$); 3-1.645(1.125$^{.5}$)]=(1.26, 4.74)

Z=2 is within 90% CI, so do not reject null hypothesis that there are no calendar year effects.

No CY Effects

Part b: 0.25 point

Sample Answer 1

Company can strengthen case reserves for all AY during a particular calendar year.

Sample Answer 2

Change in the claim settlement rate, like increasing the speed of settlement starting at a given date.

Sample Answer 3

If a company changes how it handles small claims (i.e. starts processing them faster) as of a point in time, this can affect multiple AYs and show up in the triangle as a CY effect.

Sample Answer 4

A company may change its claim processing system in a calendar year, impacting claims from all accident years.

EXAMINER'S REPORT

Candidates were expected to be able to test for calendar year impacts and identify causes of those impacts. In general, most candidates performed well on this question, with the majority of errors being caused by errors in calculations.

Part a

- Candidates were expected to be able to test whether there were calendar year impacts within a development triangle using the method outlined by Mack; "Measuring the Variability of Chain Ladder Reserve Estimates". This paper contained a numerical example illustrating the method, which candidates were expected to understand and recreate.

- Candidates generally performed well on this question, clearly demonstrating an understanding of the learning syllabus. Candidates were typically able to set up the solution correctly and errors occurred in calculating the solution. The most common errors was an error in calculating E[Z] and/or not showing supporting calculations of E[Z].

- Other errors included not identifying development factors as "high" or "low", miscalculating Z, or not taking the square root of Z.

Part b

- Candidates were expected to be able to identify one internal company action which may lead to a calendar year impact.

- The majority of candidates received full credit on part b of this question. Candidates who did not receive credit most commonly listed an external influence (such as inflation or legislative changes) or provided answers that were too vague, such as "reserve change".

QUESTION 6

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: 2 points

Sample Answer 1

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

AY	12-to-24 Months X	24-to-36 Months Y	(X - E[X])	(Y - E[Y])	(X - E[X])^2	(Y - E[Y])^2	(X - E[X]) × (Y - E[Y])
2011	0.6000	0.3750	(1.5443)	0.0207	2.3850	0.0004	(0.0319)
2012	4.0000	0.1000	1.8557	(0.2543)	3.4435	0.0647	(0.4720)
2013	1.8330	0.5880	(0.3113)	0.2337	0.0969	0.0546	(0.0727)
Mean	2.1443	0.3543		Σ	5.9254	0.1197	(0.5766)

$$r = \frac{-0.5766}{(5.9254 \times 0.1197)^{.5}}$$

r= -0.6846

n= 3

DF = n-2

DF = 1

t-statistic = 6.3140

$T = r \times [(n - 2) / (1 - r^2)]^{.5}$

$T = -0.6846 \times [(3 - 2) / (1 - (-0.6846)^2)]^{.5}$

T= -0.9393

ITI = 0.9393

Since 0.9393 < 6.3140, the correlation between the columns is not significant.

Sample Answer 2

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

AY	12-to-24 Months X	24-to-36 Months Y	XY		$(X - E[X])^2$	$(Y - E[Y])^2$
2011	0.6000	0.3750	0.2250		2.3850	0.0004
2012	4.0000	0.1000	0.4000		3.4435	0.0647
2013	1.8330	0.5880	1.0778		0.0969	0.0546
Mean	2.1443	0.3543	0.5676	Σ	5.9254	0.1197
				n	3	3
				Variance	1.9751	0.0399
				Standard Dev.	1.4054	0.1998

$$r = \frac{0.5676 - 2.1443 \times .3543}{(1.4054 \times 0.1998)}$$

r= -0.6846

n= 3
DF = n-2
DF = 1
t-statistic = 6.3140

$T = r \times [(n - 2) / (1 - r^2)]^{.5}$

$T = -0.6846 \times [(3 - 2) / (1 - (-0.6846)^2)]^{.5}$

T= -0.9393
ITI = 0.9393

Since 0.9393 < 6.3140, the correlation between the columns is not significant.

Sample Answer 3

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

AY	12-to-24 Months X	24-to-36 Months Y	XY	X^2	Y^2
2011	0.6000	0.3750	0.2250	0.3600	0.1406

2012	4.0000	0.1000	0.4000	16.0000	0.0100
2013	1.8330	0.5880	1.0778	3.3599	0.3457
Mean	2.1443	0.3543	0.5676	6.5733	0.1655
Mean^2	4.5982	0.1256			

$$r = \frac{0.5676 - 2.1443 \times .3543}{((6.5733-4.5982) \times (0.1655 - 0.1256))^{.5}}$$

r= -0.6846

n= 3
DF = n-2
DF = 1
t-statistic = 6.3140

$T = r \times [(n - 2) / (1 - r^2)]^{.5}$
$T = -0.6846 \times [(3 - 2) / (1 - (-0.6846)^2)]^{.5}$
T= -0.9393

Since 0.9393 < 6.3140, the correlation between the columns is not significant.

Part b: 1 point

$$T_k = 1 - \frac{S_k}{n(n^2 - 1)/6}$$

AY	12-to-24 Months X	24-to-36 Months Y	Rank X	Rank Y	Rank $(X-Y)^2$
2011	1.600	1.375	3	2	1
2012	5.000	1.100	1	3	4
2013	2.833	1.588	2	1	1
			S_2 =	Σ	6

I= 5
n= 3
k= 2
I-k-1= 2

$$T_2 = 1 - \frac{6}{3 \times (3^2 - 1)/6}$$

T_2= -0.50

AY	24-to-36 Months X	36-to-48 Months Y	Rank X	Rank Y	Rank $(X-Y)^2$
2011	1.375	1.091	1	2	1
2012	1.100	2.000	2	1	1
			S_3 =	Σ	2

I= 5
n= 2
k= 3
I-k-1= 1

$$T_3 = 1 - \frac{2}{2 \times (2^2 - 1)/6}$$

T_3= -1.00

$$T = \frac{\Sigma(I-k-1)\times T_k}{\Sigma(I-k-1)}$$

$$T = \frac{-0.5\times 2 + -1\times 1}{(2+1)}$$

$$T = \frac{-2}{3}$$

T= -0.67

Part c: 0.5 point

Sample Answers

- Avoid an accumulation of error probabilities
- More important to know whether correlations globally prevail than to find a small part of the triangle with correlations.
- At a 10% level of significance, 10% of the pairs of columns could show up as significant just by random happenstance. A single significant correlation would not be a strong indication of correlation within the triangle.

EXAMINER'S REPORT

Overall, many candidates performed very well on this question. Based on the knowledge statements, candidates should know key assumptions of the chain ladder models and how to test these assumptions. The question tests the candidates' understanding of approaches to test whether age-to-age factors are independent.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

Part a
Candidates were expected to execute the mechanics of Venter's correlation test, calculating all components of the formula. Candidates performed well on this part. The most common mistake was not considering this a two tailed test and using -0.94 < 6.314 instead of |-0.94| or -6.314 < -0.94 < 6.314.
Part b
Candidates were expected to execute the mechanics of calculating the Spearman rank correlation coefficient, calculating all components of the coefficient. Candidates performed well on this advanced correlation test. The most common mistakes included calculation errors or missing the T_k formula.
Part c
Candidates were expected to know how to compare correlations for the data triangle as whole to column-by-column correlations. This was a somewhat challenging question as most candidates would either present a single reason or provide two reasons that were paraphrases of each other. An example of this would be stating that comparing columns would lower the credibility of the measured correlations, and also stating that observed correlations in adjacent columns could be due to random variation.

QUESTION 7

TOTAL POINT VALUE: 1.75

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

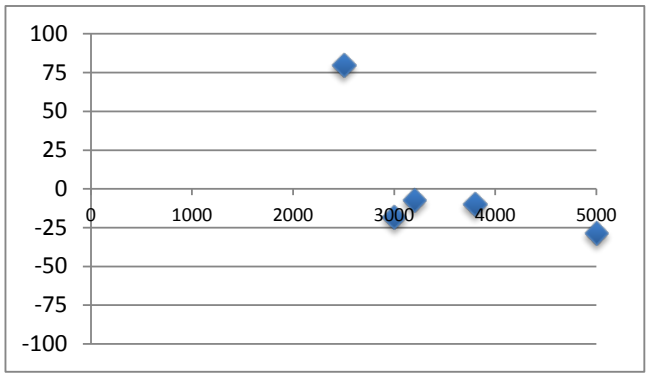
Part a: 1.25 points

Sample Answer 1

$$f = \frac{5000+8000+9000+6000+7000}{3000+5000+2500+3200+3800} = 2$$

$$\frac{Loss\ @\ 36 - Loss\ @\ 24 \times f}{\sqrt{Loss\ @\ 24}}$$

Rpt Loss @ 24 mo	Residual
3000	-18.257
5000	-28.284
2500	80
3200	-7.071
3800	-9.733



Sample Answer 2

($ millions)

$$LDF_{24-36} = \frac{5+8+\cdots+7}{3+5+\cdots+3.8} = 2$$

	(1)	(2)	(3)=2×(1)	(4) = $\frac{(2)-(3)}{\sqrt{(1)}}$
AY	L_{24}	L_{36}	LDF×L_{24}	r_i
9	3	5	6	-0.577
10	…	…	10	-0.894
11	…	…	5	2.5298
12	…	…	6.4	-0.224
13	3.8	7	7.6	-0.308

Chart similar to Sample Answer 1

Part b: 0.5 point

Sample Answer 1

Variance Assumption->variance of the next period's loss is a function of age and cumulative losses to date

As losses don't appear randomly scattered around 0, (the smallest loss has a large positive residual & all others are negative) this assumption has not been met.

Sample Answer 2

3rd assumption: Variance of incremental loss was a function of loss report-to-date and age
We prefer plot that random scatter around zero
but the plot in (a) was mostly negative and one point highly positive
This violates Mack's 3rd assumption

EXAMINER'S REPORT

Candidates were expected to demonstrate an understanding of how to test Mack's chain-ladder assumptions needed for least squares optimality, in particular the variance assumption. Candidates generally scored well on this question, though some struggled to clearly define Mack's 3rd assumption.

Part a

This part required candidates to produce a scatter plot of weighted residuals. Candidates needed to compute a weighted average LDF and apply the corresponding weighted residual formula to each accident year according to Mack's methodology. The candidates were then expected to sketch a scatter plot of the weighted residuals by reported losses at 24 months.

In order to obtain full credit, candidates needed to properly calculate the weighted average LDF, document the appropriate weighted residual formula, properly calculate the weighed residuals, and provide a labeled scatter plot of the residuals against reported losses at 24 months.

The most common error was using an incorrect weighted residual formula relative to the chosen approach to calculating the LDFs.

Part b

This part required candidates to properly identify the Mack chain-ladder assumption needed for least-squares optimality that can be tested by reviewing the scatter plot from part a. Candidates were also required to explain whether the scatter plot showed that the assumption was violated.

In order to obtain full credit, candidates needed to clearly identify the assumption correctly. Candidates were also required to provide a proper conclusion of the assumption's applicability to the data based on the scatter plot in part a. A reasonable explanation of the candidate's rationale for the conclusion was also required.

Common errors included:

- Not specifying that the variance is of the next observation's cumulative/incremental loss
- Saying that the variance is of the expected loss

QUESTION 8	
TOTAL POINT VALUE: 1.25	**LEARNING OBJECTIVE:** A4: Estimate unpaid claims for various layers of claims.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answer 1

Actuary A selected a larger Θ for his exponential distribution. Therefore, a higher percentage of losses will be removed at a given limit, meaning varying limits will have a greater impact. Therefore, Actuary A will have large adjustment factors from the unadjusted LDFs.

Sample Answer 2

Actuary A's development factors will deviate further. With larger Θ in the claim size model, the LEV will change more based on what limits you're comparing. The larger the Θ, the more likely claims will be capped by the limit you're looking at since there is a higher potential for large losses with a larger mean in your claim size model. Then when looking at $LEV_{(limit)}$ / $LEV_{(base)}$ you are like to see larger differences when your mean is larger in the claim size model.

Sample Answer 3

A will deviate further because of the larger claim size parameters, since the limiting will have a bigger effect on larger claims. Therefore, when adjusting for limit, it will be a bigger adjustment when claim sizes are larger.

Part b: 0.5 point

Sample Answers (any two of which would earn full credit)

- Different AY trend assumptions.
- Different CY trend assumptions.
- If they made different trend assumptions which would cause the detrended limited means to differ.
- They could have assumed that losses develop further out than 5 periods.
- May have chosen a different claim size model distribution (e.g. gamma, pareto, etc.).
- If either actuary made a simplifying assumption about Rj, the relationship between base layer and target layer, instead of calculating them from LEVs.

EXAMINER'S REPORT

Part a

- Candidates were expected to know the interrelationships between parameters for forecasting LDFs
- Candidates were expected to understand that the higher parameters/severities selected by Actuary A would the influence the number of claims which may be capped at the selected limit in the model, therefore impacting the modeled LDFs and cause them to deviate further from the unadjusted LDFs.

• Due to the fact that we have not previously asked a similar type of question, it may have been a little more difficult for candidates to recognize what concept was being tested. • Many candidates did not understand that the values provided for each Actuary were the underlying model parameters and not values used in a triangle to calculate LDFs. • Many candidates calculated the range between development intervals 1 and 5 which did not have an impact on the deviation of LDFs. • Some candidates correctly stated that Actuary A had higher parameters, but incorrectly reasoned that the higher parameters would lead to a higher variance in the exponential distribution, which is not a true cause of the larger deviation of the modeled LDFs.
Part b
• The candidate was expected to know the inputs that go into Sahasrabuddhe's approach to calculated LDFs. • Additionally, though selecting a distribution other than the exponential was a valid answer, some candidates responded by stating two separate distributions and this did not receive full credit. • Many candidates stated that changing the Basic Limit would impact the deviation of the modeled LDFs to the unadjusted LDFs. This is incorrect because it is based on a ratio of LEVs applied to data adjusted to the Basic Limit, and therefore the impact of the Basic Limit is cancelled out and does not influence the deviation between the LDFs. • Some candidates tried to use theories/models from other portions of the syllabus, though the question specified that they were to respond in the context of Sahasrabuddhe's approach.

QUESTION 9	
TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE:** A4: Estimate unpaid claims for various layers of claims.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

Take weighted expected excess loss from industry

0.5 × 0.45 × 0.05 + 0.3 × 0.5 × 0.1+…
= 0.06025 × 50,000 = 3,012,500

Sample Answer 2

Ult = 50,000,000 × (50% × 45% × 0.05 + 30% × 50% × 0.1 + 10% × 50% × 0.2 + 50% × 60% × 0.6) = 3,012,500

Part b: 1.25 points

Sample Answer 1

R^L = 2000/5000 = .4
R_t^L = 1500/3200 = .46875
Unlimited LDF = 5000/3200 = 1.5625
XSLDF = 1.5625 × (1 – .4)/(1 – .46875) = 1.7647
Ult XS Loss = 2.5M × 1.7647 = 4,411,750

Sample Answer 2

As all reported claims have been reported as of 24 months, all LDFS are based on excess severity development:

(5000 – 2000)/(3200 – 1500) = 1.765
1.765 × 2,500,000 = 4,412,500

Sample Answer 3

3200 – 1500 = 1700 (excess severity at 24 months)
2,500,000/1700 = 1471 (# of excess claims)
1471 × (5000 – 2000) = 4,413,000

Sample Answer 4

Unlimited LDF	1.563 = 5000/3200
Limited LDF	1.333 = 2000/1500
limited to unlimited ratio @24 months	0.469 = 1500/3200

Formula : Unlimited LDF = Limited LDF × Limited to Unlimited Ratio + Excess LDF × (1-Limited to Unlimited Ratio)
1.563 = 1.333 × .469 + Excess LDF × (1-.469)

Solve for Excess LDF
= 1.765

Therefore 1.765 × $2,500,000 = $4,411,765

Part c: 0.5 point

Sample Answer 1

For: Loss ratio method in a. can provide more stable result while b. can be very volatile especially when losses reported are extreme.
Against: a. does not take into account actual loss experience.

Sample Answer 2

For: much more stable at early maturities where xs losses are thin.
Against: ignores actual emergence of losses.

Sample Answer 3

- Based on insurer's data – since the insurer has been in business a long time, their own data better reflects the characteristics of their book of business, which may be different than the industry.
- Using industry data – the industry information is more credible and less subject to distortions from individual company experience.

EXAMINER'S REPORT

Part a

Candidates were expected to use the hazard group information with 2014 earned premium to derive an estimate of ultimate losses for 2014.

The candidates performed well on part a. A common error was to think that losses under the deductible are insurer retained losses. Another common error was to use the premium × industry unlimited expected loss ratio correctly, but in a silo computing the industry excess ratio using the premiums as the only weights as opposed to using the derived losses as weights.

Part b

Candidates were expected to use the severity information with the 2014 reported losses to derive a separate estimate of 2014 ultimate losses.

Candidates performed reasonably well, generally receiving full credit for getting the correct answer via a total of 4 different approaches, as outlined above. A common error from the suggested answer is making the assumption that since all claims are reported within 24 months, the unlimited LDF is then 1.00. This ignores development on known claims which makes this assumption wrong. This fails to consider the severity development ($5k/$3.2K).

Part c

For each method above, candidates were expected to provide a reason to rely more on it rather than the other one.

Candidates fared very well on this part, though legibility was sometimes a problem, leading to no credit awarded.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 10	
TOTAL POINT VALUE: 3	**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

Part a: 0.5 point

Sample Answer 1

External systemic risks are risks external to the insurance modeling process that impact all valuation classes and claim groups. Internal systemic risks are risks that are internal to the insurance modeling process that impact all valuation classes and claim groups.

Sample Answer 2

Internal systemic risk – Risk internal to insurance liability modeling/valuation. It represents risk arising due to the fact that model can't fully replicate insurance process.
External Systemic Risk – Risk external to the insurance liability valuation/modeling process. It arises due to external changes in environment having an impact on insurance liabilities/models.

Part b: 1 point

Sample Answer 1

Event risk- Risk from catastrophes/disasters either natural or manmade.

Economic/Social risk-risk from economic/social changes like inflation.

Sample Answer 2

Event risk- Risk from large unpredicted event causing many losses to insurer (e.g. Cat).

Recovery risk- Risk from recovery (reinsurance and non-reins) in salvage and subro / reinsurer ability to pay claims.

Part c: 1 point

Sample Answer 1

Parameter selection error – uncertainty that the model will not be able to capture all the parameters and the trends.
Data error-uncertainty due to a lack of credible data, or lack of knowledge about the data.

Sample Answer 2

Data error – risk arising from lack of credible data, inadequate understanding of portfolio analyzed.
Parameter selection error – arises from fact that model can't adequately measure all

predictors of future claims costs or trends in those predictors.

Part d: 0.5 point

Sample Answer 1

Internal systemic risk may be impacted by the size of the valuation classes. If there are many valuation classes that are small in size, internal systemic risk will increase because the data will be more volatile. Internal systemic risk could also increase if non-homogeneous claims grouped are placed in the same valuation class.

Sample Answer 2

Choice must ensure valuation classes grouped together are mostly homogenous and in line with central estimate valuation. To reduce risk (of selection in parameters and others), they must show similar qualifications (e.g., mostly same development pattern) and must be sufficiently large data sets (don't split too much) so that data is still credible and reliable.

EXAMINER'S REPORT

Part a

Candidates were expected to define internal and external systemic risk. The key point to earn full credit was "internal/external to the actuarial/valuation/reserving/modeling/estimation process".

A large number of candidates did not earn full credit. Common errors included:

- Internal/external to the company/insurer
- Within/outside of the company's control
- Diversifiable or non-diversifiable
- Inside/outside of underwriting process or insurance process (no credit was given because underwriting or insurance process is too vague unless there is further explanation in the response)
- Only listing a few examples, such as "external systematic risk includes economic and social risk, event risks, etc.", or responses like "internal risk related to / associated with the valuation process, such as parameter selection error or data error"
- Internal risk is risk around / deals with valuation process (with no further explanation)
- External = everything else

Part b

Candidates were expected to identify and properly describe two external systemic risks.

Most candidates did well on this part. Common errors included:

- Simply listing an example, such as Event Risk: e.g. CAT (Note: the only exception is economic and social risk; even if the candidate simply listed inflation, credit was given for description because there is not much explanation in the text book for this particular external risk, but for all other external system risks, proper descriptions were required for full credit.)
- Mismatch between identification and description (e.g., listing economic risk, but

providing a description of the claim handling process).

Part c

Candidates are expected to identify and properly describe two internal systemic risks.

Most candidates did well on this part. Common errors include:

- Mismatch between identification and description (e.g., listing specification error, but providing a description of parameter selection error).
- Internal fraud
- The same actuary effect

Note: A few candidates mixed their responses for parts (b) and (c).

Part d

Candidates were expected to recognize the benefit of grouping valuation classes properly considering the homogeneity, credibility, and/or operation efficiency. For full credit, the candidate had to articulate the benefits of both more homogeneous and more heterogeneous valuation class groupings.

Candidates frequently misunderstood the question. Common errors included:

- no answer,
- no coherent answer,
- responses talking about how class selections need to avoid the same actuary effect,
- statements about how the incorrect selection of valuation classes can lead to unwanted correlations between classes, without any discussion of the issue of valuation class homogeneity versus data credibility issues.

QUESTION 11	
TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE:** A6: Calculate the mean and prediction error of a reserve given an underlying statistical model.

SAMPLE ANSWERS

Part a: 1.5 points

Sample Answer 1

i) ODP: $x_i y_i \phi = 75000(1/1-1/1.5) \times 1.5 = 37{,}500$

ii) Neg bin: $\varphi \lambda_i (\lambda_{i-1}) \times D_{i,j-1} = 1.25(1.5)(1.5-1) \times 50{,}000 = 46{,}875$

iii) Norm: : $\varphi \times D_{i,j-1} = 1.75(50{,}000) = 87{,}500$

Sample Answer 2

i) $\lambda = 1.5$ Variance = 1.5×25,000 = 37,500

ii) Variance = 50,000×1.5×.5×1.25 = 46,876

iii) Variance = 1.75 × 50,000 = 87,500

Part b: 0.5 point

Sample Answer 1

The negative-Binomial would achieve the goal as its format is most closely matched to the chain ladder formula.

Sample Answer 2

ODNB would achieve this since Expected value = $\varphi \times (\lambda_i - 1) \times D_{i,j-1}$

Link factor for the incremental losses

cumulative

Part c: 0.5 point

Sample Answer 1

The normal model would achieve this as both ODP and NB model cannot work where there is negative sum of increments due to variance constraints.

Sample Answer 2

Normal since this continuous pdf has a support of (-∞,+∞) (includes negative)

EXAMINER'S REPORT

Part a

Candidates were expected to know the three different variance formulas for the Over-Dispersed Poisson, the Over-Dispersed Negative Binomial, and the Normal distributions described in the Verrall paper.

A minority of the candidates received full credit (all three formulas and correct numerical answers) for this part, with the remaining candidates roughly evenly split between knowing 0, 1, or 2 formulas and then calculating the right answer.

Part b
Candidates were expected to know that the mean formulas of two of the three distributions, the Over-Dispersed Negative Binomial and the Normal, are directly comparable to the chain ladder's mean formula (because they both have the form of a LDF times a reported-to-date value). Candidates generally struggled with this part, with the common error being naming the Over-Dispersed Poisson as the appropriate distribution. Several common erroneous justifications of the ODP (or other models) were: • Same reserve estimates as chain ladder (this is true, but all models have the same reserve estimates hence this can't be used as a justification to pick one model over the others). • The model with the highest variance. • Variance matches chain ladder.
Part c
Candidates were expected to know that only the Normal distribution could easily (i.e., without adjustment to the data) handle negative incremental values because it is the only distribution of the three with support over negative values. Candidates generally did very well on this part, though some candidates named one of the other models or left the question blank.

QUESTION 12

TOTAL POINT VALUE: 1.75	**LEARNING OBJECTIVE:** A8: Identify data issues and related model adjustments for reserving models.

SAMPLE ANSWERS

Part a: 1 point

Sample Answer 1

1. When column sum is positive:

Ln(q(w,d)) = ln(q(w,d)) for q(w,d) > 0
0 for q(w,d) = 0
-ln(-q(w,d) for q(w,d) <0

2. When column sum is negative, subtract the largest negative from each incremental loss, and fit GLM using the modified triangle. Adjust the fitted incremental loss back by adding the same (largest negative) to the fitted incremental loss.

Sample Answer 2

1. Use –ln(-loss) if the incremental loss is negative.
2. Add constant to each cell in the triangle so that each cell is positive. After GLM estimation, deduct the constant from each cell.

Part b: 0.75 point

Sample Answer 1

Incremental Loss Triangle

AY	12	24	36	48
2011	1500	-200	-100	50
2012	2000	-500	250	
2013	1750	250		
2014	2200			

Column sum of age 24 is negative. The second model is more appropriate as GLM will fail with negative column sum.

Sample Answer 2

More appropriate to use method 1(subtract the largest negative value to each cell in the triangle and solve for the parameters to get the fitted mean and then add the same value for each cell) since column sum at 24 months is negative. In this case, subtract -500 from each cell. This ensures all columns sums are positive so a solution can be found.

EXAMINER'S REPORT

In general, candidates performed fairly well on this question, though it was not common to earn full credit.

Part a

Candidates were expected to know the two adjustments and most of the time they were

successful at it. However, they at times had difficulty fully explaining all the steps of each adjustment.
Part b
Candidates were expected to identify which of the two adjustments from part a. would address the data issue in the data presented here, and then to explain why it was the more appropriate adjustment to use. In most cases candidates identified the correct adjustment. However, the majority omitted an explanation for why this particular adjustment was necessary (GLM would not find a solution).

QUESTION 13	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** A9: Test assumptions underlying reserve models.

SAMPLE ANSWERS (BY PART, AS APPLICABLE)

Part a: 0.5 point

Sample Answers (any two of which would earn full credit)

- Residuals vs. Accident Year
- Residuals vs. Calendar Year
- Residuals vs. Size of Loss (Prior Cumulative, Expected Incremental, etc.)
- Normality Plot
- Box and Whisker Plot

Part b: 0.5 point

Sample Answer 1

1) If the actuary notices that variance is not constant across all residuals.
2) If the actuary notices that residuals are trending, so for example, early AYs have positive residuals and later AYs have negative residuals.

Sample Answer 2

1) Downward trend in residuals
2) Residuals become more dispersed (or less dispersed) at different parts of the plot

Sample Answer 3

1) If residuals become more spread out or have varying dispersion among periods, suggesting heteroscedasticity.

Sample Answer 4

1) If residuals become more spread out or have varying dispersion among periods, suggesting heteroscedasticity.

Sample Answer 5

1) Outliers in residuals

We also would have accepted:

The residuals in the normality plot are not tightly grouped around a straight 45 degree line through the origin.

Part c: 0.5 point

Sample Answer 1

His reasoning is not sound. Each residual is divided by the square root its expected variance based on the ODP model. Therefore if there is still variation in spread of residuals we have unexpected changes in variance and need to make an adjustment to our model.

Sample Answer 2

This could be accurate if they are raw residuals. However, if they are weighted-residuals, we would not expect to see this.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

EXAMINER'S REPORT (BY PART, AS APPLICABLE)
Part a
Candidates performed very well on this part. They were expected to identify two residuals plots, other than the one mentioned in the stem, that an actuary could choose to review. Common errors were describing residuals vs. age (as this was the example given in the question), and describing plots that do not have residuals (e.g., p-p plot).
Part b
Candidates performed well on this part. Candidates were expected to describe specific visual features of a plot that would indicate an adjustment was needed. Common errors included describing the same feature twice on different plots, describing the adjustment needed without the plot features (e.g. simply saying there was heteroscedasticity in the plot), and generally vague descriptions. Another common error was describing zero sum residuals, as this would not be identified through a plot. Although not required, many candidates created a sample plot which made it easier to interpret their intent.
Part c
Candidates' performance on this part was more mixed. Candidates were expected to directly address the argument made, reach a conclusion and provide a rationale. Many candidates do not address the argument at all and simply stated that the bootstrap model requires residuals to be iid – this response was awarded no credit as it failed to address the actuary's reasoning as instructed in the question. Other common mistakes included commenting on the variability at different ages due to claim development and agreeing that the actuary was correct.

QUESTION 14

TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE:** A08: Identify data issues and related model adjustments for reserving models. Also A10: Develop a distribution of reserves using weights and multiple stochastic models.

SAMPLE ANSWERS

Part a: 2.25 points

Sample Answer 1

* Need to adjust residuals for heteroscadasticity.

* Group residuals by AY:

2010 – 2012 have similar standard deviation

2013 – 2015 have similar standard deviation

$\sigma_{2010-2012} = 4.741$

$\sigma_{2013-2015} = 1.537$

2013 – 2015 residual adj = 4.741 / 1.537 = 3.085

2010 – 2012 residual adj = 4.741 / 4.742 = 1.000

$\max \sigma = 4.741$

$q^*(w,d) = \left(r^*\sqrt{m_{w,d}} + m_{w,d}\right)$

$q^*(3,2) = \left(5.151\sqrt{4{,}112} + 4{,}112\right)$

$q^*(4,2) = \left(-1.524\sqrt{4{,}539} + 4{,}539\right)$

$q^*(5,2) = \left(-1.94\sqrt{5{,}254} + 5{,}254\right)$

$m_{3,2} = 7{,}612 - 3{,}500$

$m_{4,2} = 8{,}749 - 4{,}210$

$m_{5,2} = 10{,}654 - 5{,}400$

AY	Unadjusted Sample Residual	AY Sampled From	Hetero-Adjustment	Adjusted r^*	$q^*(w,d)$
2012	-1.67	2014	3.085	5.152	4,442.37
2013	-4.70	2010	1 / 3.085	-1.524	4,436.32
2014	-1.94	2013	1.000	-1.94	5,113.38

Sample Answer 2

	Sample Residual	SD(Residual)	SD(AY Group)
2012	1.67	1.537	4.741
2013	-4.7	4.741	1.537
2014	-1.94	1.537	1.537

Adjust SD based on groupings

Group 2011 – 2012

Group 2013 – 2015

Sample hetero adjusted residual

2012 $1.67 \times \frac{4.741}{1.537} = 5.15$

2013 $-4.7 \times \frac{1.537}{4.741} = -1.524$

2014 $-1.94 \times \frac{1.537}{1.537} = -1.94$

	Fitted Incremental Losses	Resampled Incremental Losses
2012	4,112	$5.15 \times \sqrt{4{,}112} + 4{,}112 = 4{,}442$
2013	4,539	$-1.52 \times \sqrt{4{,}539} + 4{,}539 = 4{,}436$
2014	5,254	$-1.94 \times \sqrt{5{,}254} + 5{,}254 = 5{,}113$

Sample Answer 3

Accident years 2010 to 2012 have similar standard deviations, so group together. Other accident years do not have similar standard deviation. Selecting groups as follows:

AY	Std Dev	Hetero Group	Adj Factor
2010	3.571	1	4.471/4.471 = 1.00
2011	5.563	1	1.00
2012	5.797	1	1.00
2013	1.045	2	4.471/1.045 = 4.537
2014	2.503	3	4.471/2.503 = 1.894

AY	Adj Residual (r*)	Adj Residual (r*/h)
2012	1.67 x 1.894 = 3.163	3.163 / 1.00 = 3.163
2013	-4.70 x 1.000 = -4.700	-4.70 / 4.537 = -1.036
2014	-1.94 x 4.537 = - 8.802	-8.802 / 1.894 = -4.648

AY	Sampled Loss
2012	$(7{,}612 – 3{,}500) + 3.163(7{,}612 – 3{,}500)^{1/2} = 4{,}315$
2013	$(8{,}749 – 4{,}210) – 1.036(8{,}749 – 4{,}210)^{1/2} = 4{,}469$
2014	$(10{,}654 – 5{,}400) – 4.648(10{,}654 – 5{,}400)^{1/2} = 4{,}917$

Part b: 0.5 point

Sample Answer 1

The bootstrapping process assumes we can sample residuals from anywhere in the triangle. If the variance of residuals differs then our assumption of independent residuals is

not valid. Adjusting for this keeps us from having overstated or understated estimated incremental losses during each iteration (depending on how the variance in that cell relates to other cells) and keeps the bootstrap variance of loss estimate from being artificially distorted.

Sample Answer 2

Bootstrapping technique requires the residuals to be IID, then we can sample residuals from any place of the triangle. Heteroscedastic residuals violates this requirement.

EXAMINER'S REPORT

Very few candidates earned full credit for both parts of this question.

Part a

- Candidates were expected to know how to select hetero-groups based on the standard deviations provided. Solutions with different hetero-groups were given credit as long as the candidate provided justification.
- Candidates needed to recognize that sampled residuals should be adjusted for heteroscedasticity.
- Candidates had difficulty earning full credit for this part.
- Common errors include the following:
  - No justification provided for selected hetero-groups.
  - Hetero-adjustment factors were calculated using the wrong standard deviations
  - Entirely skipped hetero-adjustments.
  - Applied hetero-adjustment factors to the wrong sampled residuals.
  - Candidates failed to divide by the hetero-adjustment factors to bring the adjusted residuals back to the original distribution.
  - Some candidates did not use incremental fitted losses and applied the process to cumulative losses.

Part b

- Candidates were expected to know that residuals are independent and identically distributed in order to sample residuals from the whole triangle.
- Generally, candidates did not earn full credit for this part.
- Common errors include the following:
  - Noting that bootstrapping requires residuals that are independent and identically distributed, but did not fully explain the issue when the assumption is violated.
  - Other candidates used terms such as "the variance", "variance of incremental losses", or "losses are iid" without mentioning that it's the <u>residuals</u> that have to be IID.
  - Many candidates mentioned that it would "increase the variance of the unpaid claim estimate" which is not always the case.
  - Full or partial credit was given to candidates who explained the variance of the unpaid claims would increase or decrease due to heteroscedastic residuals.

QUESTION 15

TOTAL POINT VALUE: 2.25

LEARNING OBJECTIVE: A9: Test assumptions underlying reserve models.

SAMPLE ANSWERS

Part a: 1.0 point

Sample Answer 1

Actual percentiles (p_i)	Expected Percenties (f_i)	$\lvert p_i - f_i \rvert$
	100 × (1/n) = 100 × (1/20)	
12	= 5	7
29	100 × (2/n) = 10	19
37	15	22
40	20	20
44	25	19
45	30	15
49	35	14
50	40	10
51	45	6
52	50	2
53	55	2
58	60	2
61	65	4
62	70	8
66	75	9
67	80	13
69	85	16
71	90	19
72	95	23
84	100	16

- Max|pi-fi|= 23 < 30.4 therefore the model is validated

Sample Answer 2

p = percentile	e = [x / (n + 1) = [x / 21]	D =|p-e|
0.12	0.0476	0.0724
0.29	0.0952	0.1948
0.37	0.1429	0.2271
0.40	0.1905	0.2095
0.44	0.2381	0.2019
0.45	0.2857	0.1643
0.49	0.3333	0.1567
0.50	0.3810	0.1190

0.51	0.4286	0.0814
0.52	0.4762	0.0438
0.53	0.5238	0.0062
0.58	0.5714	0.0086
0.61	0.6190	0.0090
0.62	0.6667	0.0467
0.66	0.7143	0.0543
0.67	0.7619	0.0919
0.69	0.8095	0.1195
0.71	0.8571	0.1471
0.72	0.9048	0.1848
0.84	0.9524	0.1124

- None of the Ds are larger than 0.304 so the model is validated at 5% confidence level.

Part b: 0.5 point

Sample Answers (any two of which would earn full credit)

- There is another model that would work better.
- Insurance loss environment has experienced changes that are not yet observable in the data.
- Insurance process is too dynamic to be captured by a single model. OR Black swan type events can distort the modeled process. The insurance process is just too complex.
- Underlying data used to calibrate the model is missing crucial info necessary to make a reliable prediction.
- Because we only use a small sample of universe data we are likely to miss-estimate parameters.

Part c: 0.75 point

Sample Answer 1

- The Mack model uses the reported to date cumulative loss to estimate the ultimate loss level for AY. The reported to date is fixed and thus the row level acts as a fixed parameter.
- By allowing the row level to vary, we can add more volatility to the Mack model (which produced light tails on incurred data). The Leveled Chain Ladder model does this.

Sample Answer 2

- Mack assumes that AYs are independent.
- If we remove this assumption and allow AY to be correlated and vary the level of the prior loss we can produce the CCL (Correlated Chain Ladder) model which passes the K-S test due to adding increased variation in the loss projection.

Sample Answer 3

- One shortcoming of the Mack model is it only provides mean and variance, not a full distribution.
- An alternative is the ODP Bootstrap as its output provides a full distribution in the form of the simulated results.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

Sample Answer 4

- A shortcoming of Mack model is it doesn't capture the speeding settlement rate in today's environment.
- We can use the Changing Settlement Rate (CSR) model instead to allow incorporation of a variable to represent settlement rate and let it increase over time.

Sample Answer 5

- One shortcoming of the Mack model is that it doesn't allow for incorporating expert opinion and calculate a prediction error around an incorporated expert opinion.
- An alternative is a Bayesian credibility model which allows for incorporation of expert opinions and valid prediction errors estimates.

EXAMINER'S REPORT

- Candidates were expected to know the main ideas presented in the Meyers paper.
- The candidates in general scored well on part a, relatively well on part c, and not very well on part b.
- The biggest problem candidates had on b. and c. was to distinguish between a shortcoming itself and the result of such.
- Also, Meyers' language in describing his findings was confusing to the candidates. Meyers commonly refers to low standard deviation as "light-tail" feature of the distribution (and Mack doesn't give the distribution, only its mean and variance). Same with "biased high" feature of the distribution describing the mean of model distribution being higher than the actual mean. These two descriptions appeared in almost two-thirds of the answers (to both b. and c.) and very often they were not explained, and very often given as shortcomings to either reserving models in general or to Mack's model in general.

Part a

Candidates were expected to know how to perform the K-S test over a uniform distribution, with the critical value given.

- Candidates in general scored well on this
- Candidates were allowed to use n or n+1 in the denominator for uniformly distributed percentiles (f_i). We accepted both answers, following Meyers. When using n+1 as the denominator, the most common error was not to use the absolute value in the test (the biggest absolute value had a positive difference).

Part b

Candidates were expected to know common challenges to reserving models.

- Common errors were providing answers that were too general or too similar. For example, some candidates responded with "could be biased high" and "could be biased low", which are not distinct challenges to reserving models.
- Another common error (and related to the one above) was confusing the model features or challenges to the model with the results of the model.

Part c

Candidates were expected to know the shortcomings to Mack's model and how they could be overcame by other models (either proposed by Meyers or in other papers)

- The most common error was to confuse the result of the shortcoming ("light-tail", "bias high") with the shortcoming itself (such as ignoring CY effects). Also, not understanding that the resulting "light-tails" or "high bias" were present because of the features of the

data set on which the model was tested. One cannot make generalizations about the model when testing it on one set of data only, even if the data is fully credible, but generalizations were made very often (including not being specific about in which types of triangles, incurred or paid, the effect was observed).

- While candidates could generally propose a different model, they often struggled to describe why that model represented an improvement.

QUESTION 16

TOTAL POINT VALUE: 1.75	**LEARNING OBJECTIVE:** A12: Adjust primary methods and data to be used for reinsurance reserving.

SAMPLE ANSWERS

Part a: 1.0 point

Sample Answer 1

SB ELR = $\sum ARL\ (k) / \sum ARPP(K) Rlag(k)$ = 22,500/35,600 = 0.625

Rlag = 1/LDF

SB IBNR = $\sum ARPP(k)(1 - Rlag(k)\ ELR = 38{,}375{,}000$

Sample Answer 2

ELR = $22{,}250 / \%rpt\ x\ Adj\ prem = 22{,}250 \Big/ 21{,}000\left(\frac{1}{1.25}\right) + \cdots + 24{,}000\left(\frac{1}{8}\right)$ = 0.625

IBNR = 21,000 (0.625) (1 – 1/1.25) + … + 24,000 (0.625) (1 – 1/8) = 38,375

Part b: 0.75 point

Sample Answer 1

P_{2014} = 0.2

Z = 0.2 × 0.8 = 0.16

R_{CL} = 4,000/0.2 × 0.8 = 16,000

R_{SB} = 25 × 0.625 × 0.8 = 12,500

$IBNR_{Cred}$ = 0.16 (16,000) + (1 – 0.16) (12,500) = 13,060

Sample Answer 2

CL res = Rep × LDF_{ult} – Rep

2014: 4,000 × 5 – 4,000 = 16,000

Z = p × cred = 0.2 × 0.8 = 0.16

Wtd res = z (CL) + (1 – z) SB

(0.16) (16,000) + (1 – 0.16) (12,500) = 13,060,000

EXAMINER'S REPORT

Part a

Candidates were expected to execute the mechanics of the Stanard-Bühlmann method to estimate IBNR. Generally, candidates performed very well and most candidates earned full credit or lost credit only for a computation error.

The most common error was to use 22,500 for reported losses instead of the given 22,250.

A limited number of candidates also used Earned-Risk Pure Premium data instead of the Adjusted Premium data to calculate the unused premium in the last step of the calculation.

Part b

Candidates were expected to know Patrik's approach to credibility-weighting the IBNR estimated in part a. against a chain-ladder IBNR estimate. Generally, candidates performed well and most candidates earned full credit or lost credit only for a computation error.

The most common errors were:

- Calculating IBNR in total for the 4 AY data and not isolating AY2014 or using a wrong AY (e.g., AY2015)
- Not calculating the credibility weights properly. Many candidates used Z=0.8 directly as provided in the question instead of applying the report-lag factor to it.
- Using a wrong ultimate loss number for the SB component. Some candidates applied the ELR to the adjusted premium and subtracted reported losses.
- Using ultimate number for CL method as if it is an IBNR number (i.e., not deducting 1.0 from the LDFs).

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QUESTION 17	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** A11: Compare and contrast reinsurance and primary reserving procedures.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answer 1

1. There is persistent upward development of claims
2. IT Systems & Data coding issues

Sample Answer 2

1. Reinsurance reserves exhibit persistent upward development
2. Industry reinsurance data may not be useful due to heterogeneity

Part b: 1 point

Sample Answer 1

1. Primary insurers have a tendency to under-reserve for ALAE & to set claims case reserves to a modal value
   Trend has a greater impact on excess losses
2. Systems are not updated quickly enough to keep up with changing needs
   The heterogeneity involved in reinsurance makes data coding more challenging

Sample Answer 2

1. Due to under reserving of ALAE, modal reserving by the cedant and increasing inflation
2. For industry data heterogeneity may be caused by aggregation of cedant LOBs into one LOB for reinsurance reporting; also RAA data is only distributed once every two years.

EXAMINER'S REPORT

Nearly all responses came from the Patrik paper, but additional responses not explicitly identified in the text were accepted if the candidate provided a solid explanation.

The most common reason for candidates to lose credit was if they only provided one support example for each problem identified in part b. Additionally, some candidates lost credit because they provided underlying causes related to the two problems identified in the stem of the question, rather than referring to the answers they provided in part a., as explicitly required.

Generally, candidates performed well on this exam question and demonstrated a strong understanding of this learning objective.

Part a

Candidates were expected to identify two technical problems with reinsurance reserving related to the scenario presented in the item stem. Candidates generally received full credit for this part.

Part b

Candidates were expected to identify causes of the problems identified in part a. Candidates generally performed well, though not quite as well as on part a. They typically could identify one cause for each technical problem, but often struggle to identify a second one.

QUESTION 18

TOTAL POINT VALUE: 3

LEARNING OBJECTIVE: A14: Forecast premium reserves.

SAMPLE ANSWERS

Sample Answer 1

$$\text{CPDLD} = \frac{\sum \text{PDLD} \times \text{\% Loss Emerged}}{\sum \text{\% Loss Emerged}}$$

CPDLD1 = 1.5
CPDLD2 = 0.588
CPDLD3 = 0.491
CPDLD4 = 0.4

Expected Future Loss = Ult – Loss Reported as of Prior

AY	Expected Future Loss
11	2,000
12	24,500
13	44,500
14 & 15	280,000

Expected Future Prem = Expected Future Loss × CPDLD
Prem Asset = Expected Future Prem + Prior Booked – Current Booked

AY	CPDLD	Future Premium	Premium Asset	
11	0.4	800	-1,200	
12	0.491	1,2029.5	10,029.5	
13	0.588	26,166	21,166	= 330,000 + 26,166 – 335,000
14 & 15	1.5	420,000	-5,000	
			24,995.5	

Sample Answer 2

CPDLD = sumproduct of future incurred loss dev and PDLD / ∑

Retro Adj	CPDLD
1	1.5
2	.588
3	.4913
4	.4

Year	Next Retro is	Est Future Prem
11	4	800
12	3	12,037
13	2	26,166
14	1	420,000
15	1	

Est Future Prem = (Ult loss – loss reported at prior) × CPDLD of next adj

Prem asset = prem from prior adj + est future prem – premium booked now

Prem asset = 1,574,003 – 1,549,000 = 25,003

EXAMINER'S REPORT

Candidates were expected to know most calculations and how to interpret the item, with the understanding that it requires a long calculation with many subtle details.

The most common errors candidates made were simple calculation errors or calculator errors. Also, a few candidates:

- Did not calculate expected future loss correctly
- Applied the CPDLD ratios to the wrong periods
- Used PDLD ratios instead of CPDLD ratios
- For the Premium asset formula, added current booked premium to expected future premium and subtracted prior booked premium (whereas they should have added prior booked premium to expected future premium and subtracted current booked premium)

Most candidates did very well (either received full credit or lost credit only for minor calculation errors).

QUESTION 19

TOTAL POINT VALUE: 3	**LEARNING OBJECTIVE:** B1: Calculate the effect of loss and expense reserve requirements and regulatory or rating agency capital requirements on the free cash flow to equity for a P&C insurer. 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: 0.5 point

Sample Answer 1

$k = r_f + \beta\,(E(r_m) - r_f) = 0.02 + 1.25 \times (0.06) = 0.95$

Sample Answer 2

$k = 0.02 + 1.25 \times (0.06) = 0.95$

Part b: 2.5 points

Sample Answer 1

Use highest capital requirement for each year

Loss reserves cancel out in FCFE equation – don't include

FCFE = NI + Net Borrowing + Non-Cash Charges - Δ capital - Δ WC

CY	**2017**	**2018**	**2019**
NI	80	100	140
Beg Equity	1000	1017	1035
Ending Eq	1017	1035	1040
Net Borrow	12	0	15
↑ Cap	17	18	5
FCFE	75	82	150
ROE	0.08	0.098	0.135
Reinv	0.2125	0.18	0.036
Growth	0.017	0.0176	0.0048

Since there is no trend in growth and it's volatile use an avg = 0.013

$$\frac{75}{1.095} + \frac{82}{1.095^2} + \frac{150}{1.095^3} + \frac{150\,(1.013)}{\frac{0.095 - 0.013}{1.095^3}} = 251.13 + 1411.38 = 1662.51\text{M}$$

Sample Answer 2

FCFE method

FCFE = Net Income + (graders note: the written out formula was incomplete, but used correctly and given full credit)

Selected Max(Min Cap AA Rating, Min Cap regulator, Min Cap Growth)

	2017	2018	2019	2020
Beginning Equity	1000	1017	1035	1040
NI	80	100	140	
Δ Capital	17	18	5	
Net Borrow	12	0	15	
FCFE	75	82	150	

$$PVFH = \frac{75}{1.095} + \frac{82}{1.095^2} + \frac{150}{1.095^3} = 251.13$$

Calculate Growth ROE = NI/RE	**2017** .08	**2018** .098	**2019** .135	**Selected** 13%	← going with close to CY 19, since trending upward
Reinvest = ΔCap/NI	.2125	.18	.036	12.5%	←weighted average, also trending downward which takes that into account without going all the way to 4% (if anomaly)

G = ROE × reinvest rate = 13% × 12.5% = .01625

$$TV = \frac{150(1.01625)}{.095 - .01625} = 1935.714$$

$$PVTV = \frac{1935.714}{1.095^3} = 1474.34$$

Value of Company = 251.14 + 1474.34 = 1725.47 (in 000,000)

EXAMINER'S REPORT

- On this question, the candidate was expected to know how to value the equity of a P&C insurer based on its free cash flow to equity
- Candidates generally scored well, either gaining full credit or taking slight deductions for minor mistakes/lack of explanation.
- Generally speaking, the candidates understood what was asked of them. Many, however, lost partial credit for various mistake (see part b for details)

Part a

- Candidates were expected to know how to calculate the required return for the firm.

- While mistakes weren't common, of the responses that were incorrect, the most common error was to use the market risk premium as the expected market return.

Part b

- Candidates were expected to know how to calculate the value of the firm through free cash flow to equity.
- Most candidates appeared familiar with how to go about addressing this problem. Mistakes were mostly in details such as:
  - Choice of equity at the end of each year
  - Inclusion/exclusion of net borrowing in the FCFE calculation
  - Inclusion/exclusion of reserves in the FCFE calculation
  - To calculate the growth rate, relying on a formula that was specific to one example in the textbook: Reinvested Rate = (Net Income – Free Cash Flow) / Net Income. This example did not include a debt component.

    As there is a debt component in this item, the formula to use is Reinvested Rate = (Net Income – Free Cash Flow + Δ Debt) / Net Income, or Reinvested Rate = Δ capital / Net Income. Alternatively, growth rate could have been calculated directly as ending equity/beginning equity – 1.
- The terminal value and the discount factors were generally calculated correctly
- Some candidate lost partial credit for a lack of explanation or for not clearly stating assumptions for the following
  - Choice of equity at the end of the year
  - Choice of growth rate if selection was based on some multi-year average and/or excluded an "abnormal" year

QUESTION 20	
TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE:** B3: Value the equity of a firm using comparative or relative valuation methods based on multiples of selected financial variables obtained from either peer companies or from underlying fundamentals.

SAMPLE ANSWERS

Part a: 1 point

Sample Answer 1

Wtd-Avg P-E Ratio using P-C Peer Companies=[(12.9)(15)+(11.7)(9)+(11.1)(3)+(19)(1)] / 28 = 12.54
Insurer Value=(12.54)(700M)=8.778 Billion
Wtd-Avg P-BV Ratio using P-C Peer Companies=[(1.4)(15)+(1.5)(9)+(1.2)(3)+(1.9)(1)] / 28 = 1.43
Insurer Value=(1.43)(6B)=8.57 Billion
Avg Insurer Valuation=(8.778B+8.57B)/2=8.674 Billion

Sample Answer 2

use straight avg of P&C Co
Avg PE=(12.9+11.7+11.1+19)/4=13.675
Avg P-BV=(1.4+1.5+1.2+1.9)/4=1.5
P to E= 700M × 13.675 = 9.5725B
P to BV = 6B × 1.5 = 9B
Avg=9.29 Billion

Note: using the median, as opposed to a weighted average or straight average, was also accepted.

Part b: 0.5 point

Sample Answer 1

Market Multiples use market values which can be volatile depending on the market's outlook at the time

Sample Answer 2

Risk profiles can vary greatly by P&C company. Due to primary lines written (long vs short tail), types of coverage (excess, primary), etc. So 1 company's ratio may not reflect another's ratios because of the differences.

Sample Answer 3

Each industry may have different mix of business and leverage ratios, leading to different k, g, so using market multiples may lead to inaccurate results for calculating value of individual firm.

Part c: 0.5 point

Sample Answer 1

We can use the averages over several months or years in market values to try to get rid of some of this volatility.

Sample Answer 2

To counter this, identify 'pure players' that operate in only one LOB & use this to value the insurer in pieces based on premium volume.

Part d: 0.75 point

Same Answers for the one advantage

- Transaction multiples involve negotiations between sophisticated parties making the valuation more meaningful.
- Not subject to random market fluctuations, should have been valued by careful analysis.
- Transactions done by people/experts involved in the companies > would have best estimate of values.

Same Answers for the disadvantages, any two of which would earn credit

- generally m&a buyers overpay for acquired companies
- another weakness is IPOs have historically been underpriced according to some research
- Control Premiums – firms will often overpay to get control of another firm.
- underlying economic assumptions: historical transactions took place in a different economic environment
- transaction multiples are using financial info at the time of the transaction thus may not be up-to-date enough.
- Trans. multiples usually include some optimism for synergies created by the merger.

EXAMINER'S REPORT

- The candidate was expected to demonstrate fundamental knowledge and application of valuation methods.
- Candidates generally scored well on the question, particularly part a.
- Candidates struggled most with part d., often confusing market multiples with transaction multiples.
- A common error across parts b., c., and d. was providing insufficiently clear and descriptive responses.

Part a

Candidates were expected to:

1. use proper peer companies in the sample
2. calculate an appropriate multiplier for the sample group of companies
3. estimate the firm's value using P-E and P-BV
4. to use *both* multiples to estimate the firm's value

Common errors:

- Candidates included Life and/or Health company in the peer group.
- Candidates excluded P&C 1 from the peer group.
- Candidates did not follow the estimate through the end using *both* multiples to estimate the firm's value.

Part b

Candidates were expected to EITHER:

1. cite the fluctuation of market prices over time AND how such fluctuations can impact the valuation range of a price-based multiple

OR

2. cite the necessary qualities of an appropriate peer group and/or the perils of constructing an inappropriate peer group AND how the inclusion of an inappropriate peer

can have an undue effect on the leveraged multiple valuation.

- Common errors:
  - Candidates would merely say "different" or "similar" with respect to construction of a peer group without giving any description of what "different" or "similar" could mean.
  - Candidates would merely cite β (beta) as the differentiator of inclusion/exclusions.
  - Candidates would cite capital-size as a reason to exclude a company, but Goldfarb does not recommend using capital-size exclusively as a reason to exclude a company. (In fact, Tables 29 and 31 include AIG in the estimation which is ~10× the average size of the other companies in the peer group.)

Part c

Candidates were expected to EITHER:

1. propose using a multi-period average of firms' prices to reduce the impact of market fluctuations on P-E and P-BV multipliers

OR

2. propose the pooling of pure play companies and then weight the respective pure play multiples to create a portfolio-wide multiple that is appropriate for the company being valued.

Common errors:

- Candidates proposed expanding the pool of companies outside of peer-industry group (e.g., include Life and Health, or even Banks or Finance as a whole) to smooth fluctuations.
- Similar to Part b) above, candidates would suggest using "similar" companies no further description of what "similar" could mean. Candidates were not required to use the term "pure play", but to describe the idea and/or give examples.
- Candidates would propose pooling companies based merely on β (beta).
- Candidates did not mention the weighting of pure play multiples to generate an appropriate portfolio multiple.

Part d

- Candidates were expected to cite one advantage and two disadvantages of *transaction* multiples.
- Candidates could offer concise critiques of transaction multiples. Candidates could also combine disadvantages into a broader critique. For example, "Studies show IPOs tend to underprice, while M&As tend to overpay."
- Common errors:
  - Instead of discussing transaction multiples, candidates described advantages and disadvantages of *market* multiples.
  - As the advantage, candidates stated that it was "easier" to generate a valuation using transaction multiples.
  - Candidates wrote that a transaction multiple was more reflective of a true or real market price than a market multiple because it was based on an agreement between two parties. This was not credited as market prices are also determined by buy-sell agreements between buyers and sellers in the stock market on a frequent, individual basis.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 21	
TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE:** C1: Demonstrate how insurance and financial risk can be analyzed quantitatively.
SAMPLE ANSWERS (BY PART, AS APPLICABLE)	
Characteristic i: 0.5 point	
Sample Answer 1 Strength – The process should be dynamic, and ready to respond to changing conditions *Sample Answer 2* Strength – risk landscape is necessary to be able to ensure processes are working as intended and to identify new risks	
Characteristic ii: 0.5 point	
Sample Answer 1 Weakness – Operational and strategic risk are important to consider, even if they are difficult to quantify *Sample Answer 2* Weakness – Other risks like operational and strategic risk can cause insolvency of an insurance entity	
Characteristic iii: 0.5 point	
Sample Answer 1 Strength – Only critical risks should be managed. This ensures efficient use of resources *Sample Answer 2* Strength – Program should focus on key risks that are material to the company. Short tailed, low exposure, and in runoff all point towards this risk not being material to the company as a whole. *Sample Answer 3* It could be either. We should examine all sources of risk but due to the size it is unlikely to have a material impact. If it won't have a material impact, it might be better to focus resources on other important risks (possible strength)	
Characteristic iv: 0.5 point	
Sample Answer 1 Weakness – The model should account for the capability to exploit risk when the outcome is favorable *Sample Answer 2* Weakness – Favorable outcomes should also be considered. Part of ERM is looking for opportunities to capitalize on good risk.	
Characteristic v: 0.5 point	
Sample Answer 1 Weakness – There could be interdependency between the two lines in the tail. Separate models would underestimate the tail correlation for extreme events.	

Sample Answer 2

Weakness: There are likely similarities in how the departments are run as they are influenced by the same company culture. This correlation should be considered. Also risks having to do with macroeconomic variables and event risk are probably correlated across personal/commercial as well. This correlation needs to be considered in the model.

Sample Answer 3

Weakness - The model needs to quantify dependencies between these lines

EXAMINER'S REPORT

For each characteristic, the candidate needed to state whether the model characteristic was a strength or a weakness, and then explain why the characteristic was a strength or weakness.

Candidates generally correctly recognized whether a characteristic represented a strength or a weakness, though they struggled with the third characteristic. They generally had more difficulty supporting their positions. More detail is provided in the individual characteristic explanations.

Characteristic i

A large majority of candidates recognized that continuous monitoring of ERM is a strength. Ideally, candidates would have stated that continuous monitoring of ERM is important in order to recognize material changes in a company's risk profile.

Characteristic ii

The vast majority of candidates recognized that an ERM model that is restricted to insurance and financial risk is not complete, and such a restriction would be a weakness of the model. Ideally, the candidate would recognize that operational and strategic risk, though challenging to quantify, should be monitored at least qualitatively. Any explanation that cited a risk other than insurance and financial was accepted. Certain risks cited by the candidates, such as reserve risk, underwriting risk, and asset risk, are part of insurance or financial risks and were not accepted as examples of other risks that need to be included.

Characteristic iii

The expected response was that excluding this small risk is a strength, as ERM is meant to monitor risks that are material to a firm. Many candidates argued that excluding this risk was a weakness, as ERM is meant to be comprehensive and incorporate every risk a firm faces. This did not receive credit, as it contradicts the Brehm text.

Characteristic iv

Most candidates recognized that it is a weakness to exclude upside risk from an ERM model. Many candidates did not note that the reason why including upside risk is desirable is that it enables management to maximize firm value by taking advantage of opportunities based on upside risks detected by the model.

Characteristic v

In general, candidates did recognize that separate commercial and personal lines models are a weakness. To receive credit for the explanation, the candidate had to note that the reason why this is a weakness is that there may be correlations (dependencies) between the two lines. Simply stating that the model needs to be at an enterprise level, without citing the non-independence of the two lines of business, was not sufficient to receive credit.

QUESTION 22	
TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE:** C1: Demonstrate how insurance and financial risk can be analyzed quantitatively; C2: Describe the rationale for, methods for, and effect of managing insurance and financial risks; and C8: Describe approaches to modeling the underwriting cycle.

SAMPLE ANSWERS

Part a: 1 point

Sample Answer 1

Invest more in high yielding assets such as equity and high yield corporate bonds during soft market, and invest in more conservative assets such as treasury during hard market. Because during soft market, company is taking on less insurance risk by reducing market share, so it makes to take on more asset risk, and the extra investment income would help offset the reduction in UW income. During hard market it's the other way around.

Sample Answer 2

Shift assets more to equities when market is soft and move to bonds when market is hard. Equities typically have higher returns than bonds, so they should help make up for the decrease in UW profit in soft market. Conversely, higher UW profit in hard market will be offset by lower investment returns from bond-heavy asset portfolio. Should smooth out annual earnings.

Sample Answer 3

During soft market, invest more in taxable bonds with higher returns. During hard market, invest more in tax exempt bonds with lower return.

Justification:

1. During soft market, company suffers UW loss. The higher investment income can help offset the underwriting loss, improving performance.
2. During hard market, company with decent UW profit can use tax exempt bonds to pay less tax on the investment income from tax exempt bonds.

Part b: 0.5 point (each corresponds to the sample answer for part a. above)

Sample Answer 1

Asset risk would increase during soft markets – equities are riskier than bonds; there's a risk that market prices would decline after you invest more heavily in equities.

Sample Answer 2

Investment risk/asset risk. This is risk that company may see a drop in asset value if there's a market downturn, because now the company is investing more in higher risk asset.

Sample Answer 3

Taxable bonds with higher returns might have a longer duration, which would increase the interest rate risk.

EXAMINER'S REPORT

- This item was challenging due to its open-ended wording and the requirement to synthesize

understanding of both the underwriting cycle and asset management.

- The item's requirement to "outline and justify" a strategy requires a high level of understanding in order to construct and justify a specific practical strategy for this situation that goes beyond a simple description.

Part a

- Candidates needed to know that
  - UW profits go down during soft market and increase during hard market.
  - The company can change its investments to provide higher returns during soft market and to accept lower risk investment returns to offset the higher underwriting profit and reduce risk during the hard market.
  - The candidate was expected to provide an asset management/financial investment strategy that could stabilize earnings across the cycle; given that this company is managing the cycle by decreasing market share during soft market and increasing market share during the hard market.
  - What kind of assets would provide the require returns at different times in the cycle
  - Relatively few candidates obtained full credit.
- Common errors:
  - Many candidates did not outline a specific asset management strategy to address this situation, and instead described general approaches to asset-liability management, portfolio optimization or underwriting cycle management.
  - Addressing only one side of the cycle – soft or hard but not both. A few candidates mixed up soft and hard market
  - Many candidates interpreted "asset" in the asset management strategy as meaning "intellectual property", discussing staff retention and expense controls. This was not the intent of the question. Although maintaining investment in intellectual property is good cycle management, it would not help stabilize earnings.
  - Recommending an asset duration management strategy.
  - Matching duration/need for an asset-liability to ensure cash flow. Focused mainly on liabilities – misunderstanding that this has to be done no matter how you manage the UW cycle
  - Some just repeated the strategy to manage UW cycle i.e. increase market share when hard and decrease when soft
  - Reinsurance as an asset management strategy. Reinsurance is an important capital management tool but reinsurance reduces volatility regardless of UW cycle.

Part b

- Candidates generally performed better on this part.
- Any well-explained risk that increases as a result of the strategy outlined in part (a) was given full credit (regardless of whether the answer to part (a) was correct).
- Common errors:
  - Suggesting that interest rate risk increases as a result of using an asset-liability duration matching strategy. This strategy reduces interest rate risk.
  - Describing a risk that is not really a risk. E.g. "risk of increasing expense ratio from maintaining staff while shrinking market share." This is not a risk because it is a certainty of the selected strategy.
  - Providing a risk that is not affected by the strategy, e.g. strategic risk – there is always

strategic risk present in business decision making.

QUESTION 23	
TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE:** C2: Describe the rationale for, methods for, and effect of managing insurance and financial risks.
SAMPLE ANSWERS	
Part a: 1 point	
Sample Answer 1 Default is a very unlikely outcome in the far tail of the distribution of outcomes. The ERM model is probably not very accurate at this point in the distribution so using default avoidance as a reference point may not yield accurate results from the ERM model. Default avoidance mainly protects policyholder. However, other stakeholders (e.g., Shareholders) may care about large partial decreases in capital. To protect all stakeholders, need to choose more likely reference point than default. *Sample Answer 2* This requires selecting a capital level deep in the tail of the loss distribution, which is exactly where the loss distribution is least reliable. Default avoidance mainly protects policyholders. Shareholders can be hurt at losses lower than default level. Thus a lower level than default level may be more meaningful for the firm. *Sample Answer 3* Shareholders are impacted by a loss in value before the company is close to default. Capital requirements should consider protecting shareholders Default usually happens far out into the tail of a loss distribution where the results may not be as credible. Capital requirements should be based on a credible estimate.	
Part b: 0.5 point	
Sample Answer 1 Sufficient capital to continue servicing renewals. Sufficient capital to withstand and thrive after a catastrophe. *Sample Answer 2* Rating agency requirement- what level of capital is required to maintain rating Point at which capital could support renewal book *Sample Answer 3* Setting capital at a level that maximizes franchise value Setting capital at a level to service renewal book	

Part c: 0.75 point

Sample Answer 1

Suppose renewals are 80% of the book, so we want to minimize the chance that we will lose more than 02% of our capital in a given year. We want to set our capital = 5×TV@R90% this means one out of 10 years were are expected to lose an amount of capital equal to TV@R90% which is TV@R/ (5×TV@R90%) = 20%, so we can still service renewals.

Sample Answer 2

No more than 20% of capital to 1 an 100 event (needed to maintain capital to service ongoing business). Minimum Capital Requirement (MCR) = TV@R90% X 5. TV@R90% is the expected value of a 1 in 100 event. If that occurred, we would lose TV@R90% / (5 ×TV@R90%) = 20% of capital.

Sample Answer 3

To hold enough capital to not only survive a major CAT but thrive in its aftermath; Set minimum capital equal to 6 time 95th percentile TV@R. This ensures that an average 1 in 20 year event will deplete only 1/6th of the company's capital. So, even after this event the company will not just survive, but should have enough remaining capital to thrive.

EXAMINER'S REPORT

This was a challenging question; however, most candidates earned partial credit. In general, candidates did well at identifying meaningful reference points for setting capital requirements, while they had difficulty expressing the reference points as a TV@R measurement.

Part a

Candidates were expected to know:

- Pros and cons of default avoidance as a capital requirement
- That this requirement focuses on events in the tails of the distribution where the ERM model is least reliable and most poorly understood
- That this requirement does not recognize that significant partial losses of capital are important to shareholders which would require the threshold capital level to be well above the relatively remote default avoidance level.

The majority of candidates received partial credit or full credit. Common mistakes were:

- Indicating that default avoidance produces an excessive capital threshold leaning towards overcapitalization
- Identifying other meaningful reference points as drawbacks
- Repeated answers between parts a & b

Part b

The candidate was expected to know any two of several other reference points. A brief description of any two of many other reference points received full credit. Generally candidates did well on this part and received frequently received full credit. A common error was to provide capital requirement metrics such as VAR, TV@R, XTV@R, or EPD as reference points.

Part c

Candidates were expected to know how to express one of the capital requirements as a TV@R measurement. They were expected to select a maximum capital loss tolerance and express this as

a 1-in-y-years event, and identify the relationship of the TV@Rxx as a 1-in-y-year event, and thus express the minimum capital requirement as a multiple of TV@Rxx, or a capital requirement plus TV@Rxx as a buffer.

Common errors included:

- Defining TV@R instead of providing the requested response
- Not using TV@R in the response
- Indicating TV@R as the entire capital requirement instead of a buffer

QUESTION 24	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE:** C3: Demonstrate the properties of various risk measures and their limitations; and C4: Describe how risk measures and risk modeling, including allocation, can affect strategic management.

SAMPLE ANSWERS

Part a: 1.5 points

Sample Answer 1

- The portfolio is subject to large losses.
- Standard Deviation treats the favorable deviations the same as the unfavorable deviations.
- TVaR is linear in the tail meaning it does not treat a loss 2× as large as more than 2× as bad.
- TVaR on transformed probabilities DOES treat a loss 2× as large as more than 2× as bad. This is the better statistic to use.

Sample Answer 2

(1) SD is not appropriate as it treats favorable outcomes the same as unfavorable, with risk capital requirements. We are solely interested in unfavorable outcomes. Also, [SD] penalizes large deviations from the mean and these lines will have skewed losses.
(2) TVaR measures the average loss above VaR, but treats all losses in the tail linearly. There is high potential for skewed losses for these LOB, so a measure which treats losses in the tail linearly is not appropriate (although better than SD).
(3) WTVaR places more weight on the highly unfavorable results. This is the best measure for the skewed loss distributions. It will recognize that a loss 2 times as large as more than double the impact. Select WTVaR.

Sample Answer 3

- Standard deviation includes both negative and positive outcomes. Since we want to focus on the negative, it is not appropriate.
- TVaR would be more appropriate, but since it is linear in the tail, and these lines have potentially large tail, it is not preferred.
- TVaR transformed prob is the most appropriate since it treats a loss twice as big as more than twice as bad. Recommended.

Part b: 0.5 point

Sample Answer 1

EPD on the transformed probabilities is a tail-measure that would also address market attitudes toward risk, which is important for a book with higher likelihood in the right tail.

Sample Answer 2

Value of put option. This would take into account the market value to protect against our extreme event. So risk measure is proportional to market value which is what we want.

Sample Answer 3

Exponential Moment:

1. It considers ALL losses in the distn, not just the tails. This is good since company may suffer medium sized losses not captured by TVaR.
2. It still reflects skewness of the distn, unlike SD, so it works well for this portfolio.

EXAMINER'S REPORT

Candidates were expected to know the definition and key properties of each risk measure and its applicability to capital allocation for the given risk portfolio. Candidates generally scored well on both parts of the question. Incorrect answers typically failed to include explanations or were not responsive to the question asked.

Part a

The most common error was a failure to differentiate between TVaR and TVaR with transformed probabilities. Most correct answers noted that TVaR reflected a linear risk preference, which is inconsistent with risk aversion. A few candidates failed to indicate which measure they would recommend.

Part b

The most common error was selection of a synonym of a measure already listed in part a. Common examples were Weighted TVaR (same as TVaR with transformed probabilities) or Conditional Tail Expectation (same as TVaR). A few candidates gave answers like Wang Transform or Copula with Heavy Right Tails (HRT). These are distributions, not risk measures, which may be components of a correct answer.

QUESTION 25	
TOTAL POINT VALUE: 1.25	**LEARNING OBJECTIVE:** C6: Evaluate and select appropriate models to handle diverse risks, including stochastic approaches.

SAMPLE ANSWERS (BY PART, AS APPLICABLE)

Part a: 0.75 point

Sample Answer 1

Copula 2 because earthquakes can cause losses for both commercial property and workers compensation (so they are correlated).

The R(z) for copula 2 shows that there is correlation between the lines because R(z) > 0 as z→ 1.

Sample Answer 2

Copula 2 is better since R(z) as Z→1 is greater than 0.

In an adverse scenario like earthquake both workers compensation and commercial property will suffer loss. People may seek out of work pay and properties are destroyed.

During normal time, the two may not be as correlated

Part b: 0.5 point

Sample Answer 1

A copula can have significant tail dependence even if R(1) = 0, as the function could decrease rapidly.

A solution is to look at the function at values a bit below 1 and assess the strength of the dependence.

Sample Answer 2

It only shows you the right tail of the copula.

It should be combined with the left tail concentration function which will show what to expect in the left tail. We focus on L(z) for 0 <= z <= .5 and focus on R(z) for .5 <= z <= 1.

Sample Answer 3

There may be sparse data in the right tail which makes it volatile and hard to predict.

A solution would be using industry data as reference.

Sample Answer 4

It is a one-dimensional representation of a 2-dimensional correlation, so can be misleading. View a 3D graph of the join distribution C(u,v) instead.

Sample Answer 5

Depending on the copula used, you can see many different right tails and it's hard to

visually see which one fits best. Checking the tau of the copulas will give you a better idea of which copula best fits the data.

EXAMINER'S REPORT

Candidates generally scored better on part a. than on part b. Candidates also almost always had a response for part a but often gave no response for part b.

Part b. is worded rather broadly, allowing for many different valid responses. Most candidates had a fairly good idea of what the correct or expected answer for part a was but there were many different types of answers for part b.

Part a

Candidates were expected to evaluate two different copulas in the presence of correlation and right tail dependency.

Candidates had to:

a. Identify the correct copula.
b. Describe why the selected copula was correct by describing the function/graph.
c. Explain why there is correlation in this particular situation (earthquake causes two usually uncorrelated lines to have correlated losses in the tail).

Candidates almost always identified the correct copula. However, many candidates did not explain why the selected graph actually indicated a correlation in the right tail. Another common error was not identifying that the two lines of business were correlated because of the earthquake exposure.

Part b

Candidates were expected to identify problems with right tail concentration graphs and to offer a solution to the problem(s) they identified. Candidates had to identify one problem with right tail concentration graphs and offer a solution to that that was tied to this particular problem.

The most common error was to identify problems that were too vague or ambiguous. Also, quite often, candidates offered a solution that didn't match the issue they described. Finally, sometimes candidates offered a problem but no solution and vice versa.

Because of the open way the question was asked, there were many acceptable responses to this item and multiple different problems could be pointed out.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 26	
TOTAL POINT VALUE: 1	**LEARNING OBJECTIVE:** C7: Describe operational risk and demonstrate possible mitigation and quantification methodology.

SAMPLE ANSWERS

Part a: 0.5 point

Sample Answers, any two non-overlapping ones of which would earn full credit

- Optimistic planned loss ratio use as ELR can lead to reserve deficiencies.
- Optimistic planned loss ratio use as ELR can lead to inadequate reserve.
- Optimistic planned loss ratio use as ELR can lead to reserve conflagration.
- Optimistic planned loss ratio use as ELR can lead to premium growth in a line that is not as profitable as previously thought.
- Optimistic planned loss ratio use as ELR can lead to underpricing business.
- Optimistic planned loss ratio use as ELR can lead to rating downgrade.
- Optimistic planned loss ratio use as ELR can lead to policyholder exodus.
- Optimistic planned loss ratio use as ELR can lead to claim paying difficulty.
- Optimistic planned loss ratio use as ELR can lead to insolvency issue.
- Optimistic planned loss ratio use as ELR can lead to suboptimal investment strategy.
- Optimistic planned loss ratio use as ELR can lead to investors' dissatisfaction.

Part b: 0.5 point

Sample Answer 1

Operational risk could have been the cause of the optimistic loss ratio – an inadequate review process, perhaps, or a deficient unpaid loss estimation algorithm, or management pressured the actuaries to select more optimistically than they would have otherwise. The model's inability to accurately forecast the loss ratio would be a manifestation of underwriting risk. It may be difficult to objectively determine the level of accuracy in a model's ability to forecast a loss ratio, making it difficult to distinguish underwriting risk from operational risk.

Sample Answer 2

It is hard to tell if the forecasting model could not predict the loss ratios or was not used appropriately. If forecasting model couldn't predict accurately, it is underwriting risk (if other companies are facing the same problem). But if the model the model was not used appropriately, it is operational risk.

Sample Answer 3

Underwriting risk incorporates the random volatility inherent in insurance losses, operational risk incorporates the inadequate or failed internal processes and people. You could argue that the LR deterioration is due to underwriting risk that could not have been modeled or alternatively that the models were not appropriately used resulting in operational risk.

EXAMINER'S REPORT

Part a

A wide range of alternative answers could earn full credit.

Candidates were expected to identify two distinct potential issues.

Most candidates did well and received full credit on part a. The common errors made by candidates including repetitive answers (e.g., "Under-reserving in most recent AY" and "Under-reserving for all prior AYs").
Part b
Candidates were expected to explain the overlap between operational and underwriting risk when discussing how a loss ratio selection has played out. Few candidates earned full credit. Common errors included: • Not explaining underwriting or operational risk • Not labeling which risk is illustrated by the example candidates provided • No statement explaining why it is difficult to separate the two risks • Simply reiterating that it is difficult to separate the two risks

QUESTION 27	
TOTAL POINT VALUE: 1.25	**LEARNING OBJECTIVE:** C7: Describe operational risk and demonstrate possible mitigation and quantification methodology.
SAMPLE ANSWERS	
Part a: 0.25 point	
Sample Answer 1 To align management and owner interests *Sample Answer 2* To understand the impacts of potential divergence	
Part b: 0.5 point	
Sample Answer 1 Since incentive plan ties to growth and CR, senior management might take very aggressive growth strategy in short term that could be result in selecting wrong risks, adverse reserve development in the long run *Sample Answer 2* The incentive is structured around top line growth and combined ratios, this could lead to rate increase to obtain this which then leads to accounts leaving. Thus, top line growth and combined ratios look good but policy growth is low and could lead long term to adverse selection. *Sample Answer 3* The company/industry may be facing a soft cycle, and it will be difficult to hit both top-line growth and target combined ratios at the same time. Giving the business is long-tailed, if the company reduces prices to retain market share, this can have a significant impact years down the line.	
Part c: 0.5 point	

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

Sample Answer 1 (best response)

Intellectual property combined: "Focus on intellectual property. Maintain investments in key talent, processes and systems. Maintain core market relationships."

Sample Answer 2

Intellectual property retain top talent: "Continue to invest in staff and talent development even if market share is decreasing due to losing accounts"

Sample Answer 3

Intellectual property maintain the presence in core market channels: "Maintain presence in core distribution channels and markets during a soft market"

Sample Answer 4

Intellectual property maintain investment in systems, models and database: "Continue to invest in its systems, IT to keep important customer information"

Sample Answer 5

Underwriting incentives: "We should set incentives to support the portfolio goals, not just a naïve strategy like growth only. UW should not lose jobs or bonuses for not hitting targets during bad markets"

Sample Answer 6

Market overreaction: "Company should not overact to losing business at lower prices. They should hold prices since market will turn and they will have capacity for additional insureds which will drive growth and hit plan ratio."

Sample Answer 7

Owner education: "Advise the owners that in times of soft markets we do not want to grow as business is written at unprofitable levels. Thus we should be cutting back"

Sample Answer 8

Scenario planning: "Have a well-defined multiple scenario plan, so when the company is facing certain pressure to act on underwriting cycle change, they would have a plan already"

EXAMINER'S REPORT

Part a

Candidates mostly performed well. They were expected to identify that mangers are the agents of the owners and that owners and management potentially have divergent interests. Common errors included:

- Confusing agents and principals
- Misunderstanding "agents" to mean sales agents
- Providing a response not related to agency theory
- Using a wrong definition of "owner"

Part b

Candidates were expected to identify the conflict between behavior encouraged by the incentive plan and actions taken in the company's best long-term interests. This was the most challenging item part. By far the most common mistake was not differentiating between short-term and long-term impacts.
Part c
Candidates were expected to make suggestions for the company to improve its underwriting cycle management, and they generally performed well. One common error was to say "educate management" instead of saying "educate owners"

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 28	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE:** C8: Describe approaches to modeling the underwriting cycle.

SAMPLE ANSWERS

Part a: 0.75 point

Sample Answer 1

Delphi Method. Used to obtain expert consensus. Experts are given background information + a questionnaire. Responses are aggregated + presented to participants. Based on this participants can change their response or articulate the reasons for not agreeing. Process continues until consensus is achieved

Sample Answer 2

Competitor analysis – Combine information from trade publications, rate filings, agents, financial statements etc. to try to predict a turn in the UW cycle. The goal is to see if an unusually high number of competitors appear to be either financially distressed or very profitable

Sample Answer 3

Scenario testing: Written description of the future state of the insurance environment. Prepare management to think possible responses

Part b: 0.75 point

Sample Answer 1

Autoregressive (AR(n)) Time Series. The industry combined ratio X_t is modeled as an autoregressive time series, generally n=2 or 3 autoregressive series work well. $X_t = a + \sum_{j=1}^{n} b_j X_t - j + \partial \in$ where $\in$ is standard normal variable. This is a mean reverting process with autocorrelation coefficient + an annual disturbance distribution.

Sample Answer 2

General factor model:

$$Z_t = \mathrm{a} + \mathrm{b} \times Z_{t-1} + \sigma \times \varepsilon_i$$
$$X_t = \mathrm{d} + \mathrm{d} \times (Z_{t-1} - X_{t-1}) + \tau \times \delta_i$$

Part c: 0.5 point

Sample Answers for a "soft" approach

- Both soft and econometric approach need large quantity, variety and complexity of data
- Econometric modeling includes the recognition of human factors impacting the UW cycle making it similar to soft approach.
- It is a mixture of both while incorporating structural insight of soft approach

Sample Answers for technical models

- Both technical + econometric models require mathematical formalism + rigor greater than soft approaches.
- Technical => Statistical validity

EXAMINER'S REPORT

In general candidates did not do well on this item, especially on part c.

EXAM 7 SPRING 2016 SAMPLE ANSWERS AND EXAMINER'S REPORT

Part a
Candidates were expected to know one of the three soft approaches presented in the text and be able to provide a high-level description of it. The most common reason candidates lost credit was for an insufficient description of the chosen approach. Most candidates chose to discuss the Delphi method.
Part b
Candidates were expected to know one of the three technical approaches and to be able to provide a high-level description of the approach chosen. Formulas underlying a method were also accepted as characteristics. Note that in the second sample answer provided above, readings outside the syllabus incorporate σ into the ε term. This was accepted for full credit, and similarly for the second equation.
Part c
To receive full credit, candidates had to clearly identify the similarity and relate it to the econometric model. No credit was given for merely listing characteristics of econometric modeling without mentioning how it is similar to the other methods (soft or technical). One common reason candidates lost credit was for providing an insufficient description, such as "considers human behavior" or "judgment" for similarity with soft modeling.