Exam 7

CASUALTY ACTUARIAL SOCIETY

AND THE

CANADIAN INSTITUTE OF ACTUARIES

Expertise. Insight. Solutions.

Exam 7

Estimation of Policy Liabilities, Insurance Company Valuation, and ERM

May 4, 2017 **4 HOURS**

INSTRUCTIONS TO CANDIDATES

1. This 55.5 point examination consists of 25 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

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 18, 2017.

END OF INSTRUCTIONS

1. (2 points)

Given the following information as of December 31, 2016:

		Cumulative Reported Loss		
Accident Year	Earned Premium	12 Months	24 Months	36 Months
2014	$1,100,000	$450,000	$585,000	$614,250
2015	1,210,000	600,000	840,000	
2016	1,331,000	850,000		

- Assume no further development after 36 months.

Calculate the ultimate losses for each accident year using each of the following methods:

i. Collective loss ratio
ii. Individual loss ratio
iii. Benktander loss ratio
iv. Optimal credible loss ratio

CONTINUED ON NEXT PAGE

2. (1.75 points)

Given the following loss ratio triangle:

Cumulative Reported Loss Ratios

Accident Year	12 Months	24 Months	36 Months	48 Months	60 Months
2010	3.0%	10.0%	15.7%	37.0%	37.0%
2011	5.1%	5.1%	25.0%	44.2%	48.0%
2012	2.5%	3.0%	40.0%	57.0%	59.2%
2013	1.6%	15.7%	22.2%	21.0%	
2014	0.0%	7.8%	16.7%		
2015	6.3%	12.4%			
2016	4.7%				

- Assume a tail factor of 1.15 from 60 months to ultimate.

Calculate the accident year 2014 ultimate loss ratio using the least squares method.

CONTINUED ON NEXT PAGE

3. (2 points)

Given the following information:

Cumulative Reported Loss ($000)

Accident Year	12 Months	24 Months
2011	1,000	1,950
2012	1,200	2,650
2013	1,800	3,500
2014	1,500	3,300
2015	2,000	4,100
2016	2,400	

- Var($C_{i,k+1}|C_{i1},\ldots,C_{ik}$) is constant for all i where $C_{i,k}$ is the accumulated total claims amount of accident year i up to development year k.

a. (1 point)

Calculate the age-to-age factor for 12 to 24 months using the most appropriate formula according to Mack.

b. (1 point)

Plot the residuals against the cumulative reported loss as of 12 months and interpret the results.

CONTINUED ON NEXT PAGE

4. (1.5 points)

Given the following data and growth curve as of December 31, 2016:

Accident Year	Onlevel Premium ($000)	Reported Losses ($000)
2012	1,000	400
2013	1,300	450
2014	1,600	400
2015	1,900	250
2016	2,200	50

- $G(x) = \frac{x^{1.8}}{x^{1.8}+50^{1.8}}$, where G is the cumulative proportion of ultimate losses reported and x is the average age in months.

Test for expected loss ratio constancy across accident years.

CONTINUED ON NEXT PAGE

5. (3 points)

Given the following information as of December 31, 2016:

Accident Year	Onlevel Premium	Cumulative Paid Loss
2014	$400,000	$210,000
2015	375,000	130,000
2016	450,000	50,000

- $G(x) = \frac{x^{1.5}}{x^{1.5}+15^{1.5}}$, where *G* is the cumulative proportion of ultimate losses paid and *x* the average age in months.
- Parameter standard deviation for Cape Cod method: 175,000
- Process variance/mean scale parameter (σ^2) for Cape Cod method: 3,000

a. (1.5 points)

Calculate the total standard deviation of the Cape Cod method's total loss reserve indication.

b. (1 point)

Calculate the total loss reserve by credibility-weighting the two indications from the Cape Cod method and chain ladder method using the Benktander method.

c. (0.5 point)

Identify and briefly describe a different growth curve form that would be more appropriate to approximate the loss payment pattern for a short-tailed line of business.

CONTINUED ON NEXT PAGE

6. (2.75 points)

Given the following information:

Cumulative Paid Loss ($000)

Accident Year	12 Months	24 Months	36 Months	48 Months	60 Months
2012	500	750	950	1,050	1,100
2013	800	1,500	1,850	2,000	
2014	1,100	2,100	2,750		
2015	1,400	2,300			
2016	2,000				

- Age-to-age factors are determined by a volume weighted average of all years.
- There is no development beyond 60 months.
- Reserves are approximated by a lognormal distribution.
- The 90th percentile of the standard normal distribution is 1.28
- The accident year 2014 loss reserve estimate, R_3, has a standard error of 52.33

a. (2 points)

Construct an 80% confidence interval for R_3.

b. (0.75 point)

Construct a confidence interval for the accident year 2014 ultimate loss estimate using empirical limits.

CONTINUED ON NEXT PAGE

7. (2.25 points)

Given the following information:

Cumulative Reported Loss at $1,000,000 Limit ($000,000)

Accident Year	12 Months	24 Months	36 Months	48 Months
2013	450	1,354	2,465	3,348
2014	355	1,535	2,747	
2015	398	1,411		
2016	355			

Limited Expected Values at $1,000,000 Limit ($000)

Accident Year	12 Months	24 Months	36 Months	48 Months
2013	24	110	215	255
2014	25	115	214	265
2015	26	117	227	281
2016	26	121	236	290

Limited Expected Values at $500,000 Basic Limit ($000)

Accident Year	12 Months	24 Months	36 Months	48 Months
2013	24	109	195	223
2014	25	113	195	228
2015	26	115	204	239
2016	26	119	210	244

- Assume the 48 month to ultimate development factor is 1.000

a. (0.5 point)

Calculate the unadjusted 24 to ultimate volume weighted average development factor based on the reported loss triangle limited to $1,000,000.

b. (1.75 points)

Calculate the applicable 24 to ultimate volume weighted average development factor based on the reported loss triangle limited to $1,000,000 using the procedure outlined by Sahasrabuddhe.

CONTINUED ON NEXT PAGE

8. (3.75 points)

Given the following information:

- Two valuation classes, home and auto, are in runoff.
- Outstanding claims liabilities: \$45 million for home and \$5 million for auto.
- Internal systemic risk was analyzed using the following balanced scorecard assessment:

Risk Component	**Home Weight**	**Auto Weight**
Specification Error	5	2
Parameter Selection Error	3	5
Data Error	2	3

Potential Risk Indicators (Worst = 1, Best = 5)	**Home Score**	**Auto Score**
a. Best predictors are stable over time or change due to process changes	5	2
b. Knowledge of past processes affecting predictors	2	2
c. Number of independent models used	3	5
d. Extent, timeliness, consistency and reliability of information from business	1	3
e. Best predictors have been identified, whether or not they are used	4	1
f. Range of results produced by models	3	5

Score from Balanced Scorecard Assessment	**Home Coefficient of Variation**	**Auto Coefficient of Variation**
1.0 to 2.0	8.5%	6.5%
2.0 to 3.0	7.0%	5.0%
3.0 to 4.0	6.0%	4.0%
4.0 to 5.0	5.5%	3.5%

- Internal systemic risk has a correlation coefficient of 0.40 between valuation classes.
- Total independent risk coefficient of variation is 4.0%
- Total external systemic risk coefficient of variation is 8.0%
- The underlying distribution of insurance liabilities is Normal.
- The 80^{th} percentile of the Standard Normal distribution is 0.842

CONTINUED ON NEXT PAGE

(8 continued)

a. (0.5 point)

   Describe a scenario that could justify a score of 1 for the following potential risk indicator:

   Extent, timeliness, consistency and reliability of information from business

b. (0.75 point)

   Assign each potential risk indicator to the appropriate risk component.

c. (0.5 point)

   Calculate the home and auto weighted average balanced scorecard assessment scores, using the potential risk indicator assignments from part b. above.

d. (1 point)

   Calculate the total internal systemic risk coefficient of variation.

e. (1 point)

   Calculate the risk margin in dollars for a required probability of adequacy of 80%.

CONTINUED ON NEXT PAGE

9. (2.25 points)

Given the following information:

Unlimited Age-to-Age Reported Loss and ALAE Development Factors

12-24	24-36	36-48	48-60	60-ult
1.463	1.309	1.114	1.043	1.019

Limited Severity Relativities

Limit	12	24	36	48	60	Ult
$100,000	0.95	0.93	0.90	0.88	0.86	0.85
$250,000	0.99	0.97	0.96	0.95	0.94	0.94

Accident Year 2015 limited reported loss and ALAE at 24 months

Limit	24 months
$100,000	$3,450,000
$250,000	$3,675,000

Calculate the IBNR for the losses in the $100,000 to $250,000 layer for accident year 2015 at 24 months using Siewert's direct development approach.

CONTINUED ON NEXT PAGE

10. (2 points)

An actuary is reviewing the diagnostic results of a bootstrapping model.

a. (1 point)

Construct and label a plot of residuals that would indicate a calendar year trend due to inflation which is not reflected in the model, and describe how the residual pattern shows inflation.

b. (1 point)

Construct and label a plot of residuals that would indicate heteroscedasticity in development ages 36 and 48 compared to development ages 12 and 24, and describe how the residual pattern shows heteroscedasticity.

CONTINUED ON NEXT PAGE

11. (2.5 points)

Given the following information:

- Cumulative reported losses at 24 months for accident year 2015 are $9,000
- The following reported development factors were derived:

Age	Loss Development Factor	Cumulative Development Factor	% Reported
12	2.000	3.000	33.3%
24	1.364	1.500	66.7%
36	1.073	1.100	90.9%
48	1.025	1.025	97.6%
60	1.000	1.000	100.0%

- Incremental losses, C_{ij}, follow an over-dispersed Poisson distribution with mean $x_i y_i$ and variance $\varphi x_i y_i$
- The variable x_i represents the expected ultimate losses for accident year i.
- The variable y_j represents the proportion of ultimate losses that emerge in development year j.
- The prior distribution for x_i is gamma with mean α_i / β_i and variance α_i / β_i^2
- The dispersion parameter, φ, for the over-dispersed Poisson distribution is 9.125
- The accident year 2015 estimates for α and β are 100 and 0.01234 respectively.
- The mean of C_{ij} for this Bayesian model is:

$$Z_{ij}\left(\lambda_j - 1\right)D_{i,j-1} + \left(1 - Z_{ij}\right)\left(\lambda_j - 1\right)M_i \frac{1}{\lambda_j \lambda_{j+1} \dots \lambda_n}, \text{ where } Z_{ij} = \frac{\sum_{k=1}^{j-1} y_k}{\beta_i \varphi + \sum_{k=1}^{j-1} y_k}$$

- λ_j is the incremental chain ladder loss development factor for development year j.
- D_{ij} is the cumulative losses for accident year i as of development year j.

a. (2 points)

Calculate the incremental losses for accident year 2015 expected to emerge between 24 and 48 months of development using the model.

b. (0.5 point)

Identify and briefly describe what parameter in the model would have to change in order to produce IBNR estimates closer to chain ladder indications.

CONTINUED ON NEXT PAGE

12. (2 points)

Given the following data for a book of business:

Cumulative Paid Claims ($000)

Accident Year	6 Months	18 Months	30 Months	42 Months	54 Months	66 Months	Exposure ($000)
2011			2,000	2,250	2,500	2,750	90,000
2012		1,750	2,250	2,500	2,650		100,000
2013	1,750	3,250	4,000	4,750			130,000
2014	2,000	3,750	4,500				200,000
2015	3,000	4,000					250,000
2016	2,000						320,000

- The most recent diagonal is as of March 31, 2016.

a. (1 point)

Briefly describe four issues in the data above that should be addressed when implementing the over-dispersed Poisson (ODP) bootstrap model.

b. (1 point)

For each data issue identified in part a. above, briefly describe an adjustment to the ODP bootstrap model to address the issue.

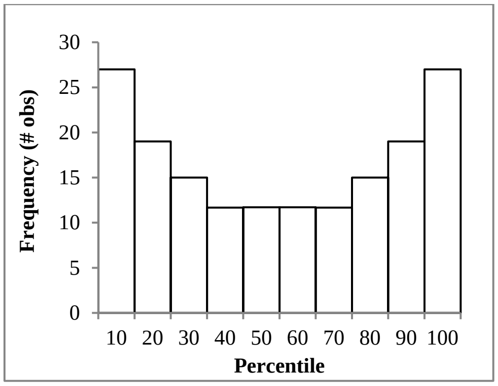
CONTINUED ON NEXT PAGE

13. (3 points)

A stochastic loss reserving model estimates that ultimate losses have an expected value of \$70 million with a 90% confidence interval from \$60 million to \$84 million.

a. (1 point)

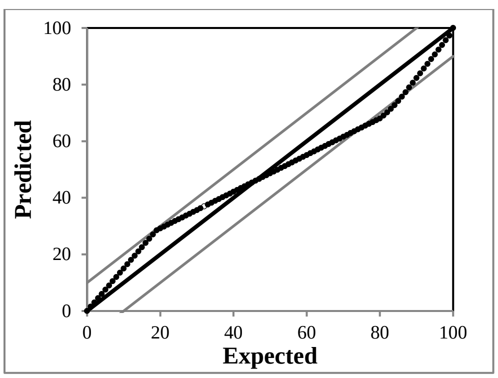
Assume the following histogram was produced during model validation:



Describe what is implied by the histogram about the accuracy of the expected value and the size of the confidence interval.

b. (1 point)

The following p-p plot was produced during model validation:



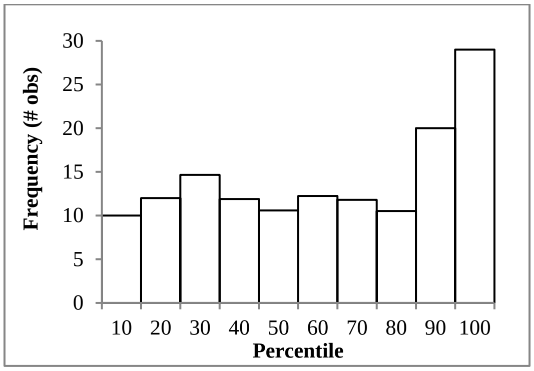
Describe what is implied by the plot about the accuracy of the expected value and the size of the confidence interval.

CONTINUED ON NEXT PAGE

(13 continued)

c. (1 point)

Assume the following histogram was produced during model validation:



Describe what is implied by the histogram about the accuracy of the expected value and the size of the confidence interval.

CONTINUED ON NEXT PAGE

14. (1.5 points)

Briefly describe six reasons why reinsurers have larger uncertainty in their loss reserves than primary insurers.

CONTINUED ON NEXT PAGE

15. (1.5 points)

Briefly describe how the following components of a loss reserve could vary for a reinsurer versus a primary insurer.

a. (0.5 point)

Additional case reserves on individual claims

b. (0.5 point)

Pure IBNR

c. (0.5 point)

Risk Load

CONTINUED ON NEXT PAGE

16. (2 points)

Given the following information ($000) as of December 31, 2016:

Accident Year	Earned Risk Pure Premium	Rate-Level Adjusted Premium	Aggregate Reported Loss	Aggregate Loss Report Lag	Chain Ladder IBNR	Bornhuetter-Ferguson IBNR
2012	5,000	5,000	3,500	.91	350	364
2013	4,500	5,500	3,300	.80	825	900
2014	5,000	6,000	2,750	.67	1,375	1,667
2015	6,500	6,500	2,500	.40	3,750	3,300
2016	7,000	7,000	2,000	.20	8,000	4,800

a. (1 point)

Calculate IBNR for accident year 2016 using the Stanard-Bühlmann method.

b. (0.5 point)

Briefly describe one advantage and one disadvantage of the Stanard-Bühlmann method.

c. (0.5 point)

Comment on an appropriate IBNR selection for accident year 2016.

CONTINUED ON NEXT PAGE

17. (1 point)

Given the following information:

- Premium Development to Loss Development (PDLD) at 3rd retro adjustment: 0.40
- PDLD at 4th retro adjustment: 0.25
- Cumulative loss development factor at 2nd retro adjustment: 1.60
- Cumulative loss development factor at 3rd retro adjustment: 1.25
- Assume all losses are settled at the 4th retro adjustment.

Calculate the cumulative PDLD ratio at the 3rd retro adjustment.

CONTINUED ON NEXT PAGE

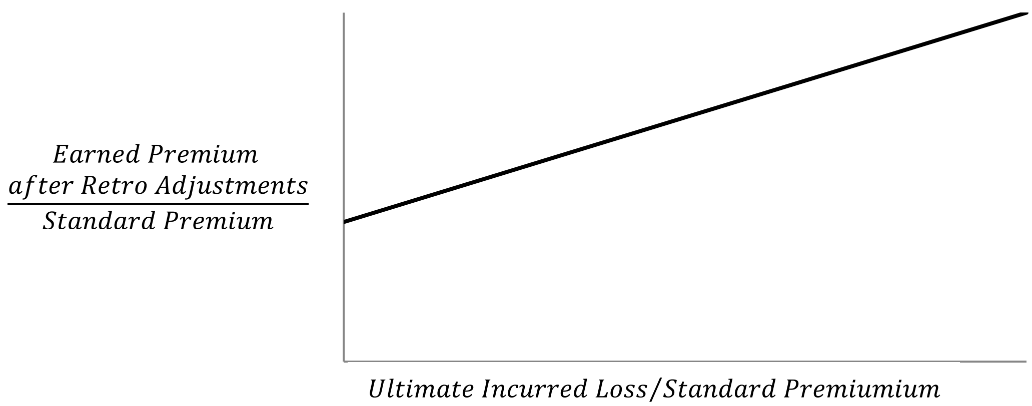
18. (2 points)

In evaluating the premium asset for a property and casualty insurance company's book of retrospectively rated policies as of December 31, 2016, the following methods have been considered:

- Chain ladder development method on historical triangles of earned premium using Part 6 of Schedule P.

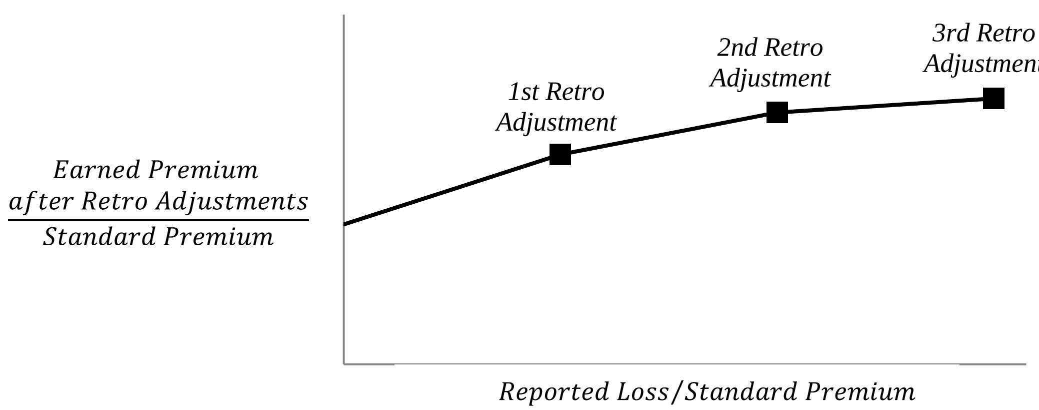
- Fitzgibbon's Linear Regression method, which produced the following graph:

Fitzgibbon's Linear Regression Method



- Premium Development to Loss Development (PDLD) method using the retro formula and average retro parameters, which produced the following graph:

PDLD Method



CONTINUED ON NEXT PAGE

(18 continued)

a. (0.5 point)

   Briefly describe one advantage and one disadvantage of using the chain ladder development method on historical earned premium triangles.

b. (0.25 point)

   Briefly describe one disadvantage of using Fitzgibbon's linear regression method.

c. (0.25 point)

   Explain why the slope factor in Fitzgibbon's linear regression method is typically not exactly unity.

d. (0.5 point)

   Briefly describe one advantage and one disadvantage of using the PDLD method.

e. (0.5 point)

   Explain why the slopes differ between Fitzgibbon's linear regression method and the PDLD method.

CONTINUED ON NEXT PAGE

19. (3.75 points)

Given the following financial information for an insurer as of December 31, 2016:

Dividend payout ratio:	75.0%
Expected equity market risk premium:	5.0%
Risk-free rate:	2.3%
Insurer's equity beta:	1.10

	Calendar Year Projections ($000)		
	2017	2018	2019
GAAP equity (beginning of period)	100,000		
Net income	20,000	22,500	25,000

a. (0.25 point)

Calculate the insurer's risk-adjusted discount rate using the Capital Asset Pricing Model.

b. (1.75 points)

Calculate the value of this insurer as of December 31, 2016, using the dividend discount model.

c. (1.25 points)

Calculate the value of this insurer as of December 31, 2016, using the abnormal earnings model, assuming forecast horizon abnormal earnings are constant after the projected periods.

d. (0.5 point)

Explain the difference in the insurer's calculated value between the dividend discount model and the abnormal earnings method.

CONTINUED ON NEXT PAGE

20. (1.25 points)

Given the following financial information ($000) for an insurance company as of December 31, 2016:

Beginning US GAAP equity	100,000
Net income	20,000
Minimum capital to maintain S&P AA rating	110,000
Minimum capital to meet management's year-end growth target	115,000
Change in loss and expense reserves	25,000
Advertising expenses (cash charge)	3,000
Amortized office furnishings expense	2,000
Net borrowing	10,000

a. (0.75 point)

Determine the company's Free Cash Flow to Equity as of year-end.

b. (0.5 point)

Briefly describe two reasons why the Free Cash Flow to Equity method is preferred over the Free Cash Flow to the Firm method when valuing property and casualty insurance companies.

CONTINUED ON NEXT PAGE

21. (2 points)

An insurance company recently expanded its homeowners line into a hurricane prone area.

a. (1 point)

Identify four forms of traditional risk management.

b. (1 point)

Briefly describe an action the insurance company can take to manage its risk for each strategy identified in part a. above.

CONTINUED ON NEXT PAGE

22. (2.5 points)

A start-up insurance company writes exclusively private passenger auto insurance, offering both liability and physical damage coverages. Based on the latest Enterprise Risk Management (ERM) review, management is confident in its capital utilization and plans to grow.

To attract and retain customers, the insurer is considering expanding into one of the following three lines of business:

- Renters
- Homeowners
- Livery conveyance (commercial coverage for insureds that use their personal vehicle and drive part-time for ridesharing companies such as Uber, Lyft, etc.)

a. (0.25 point)

Explain why parameter risk is a key source of uncertainty in enterprise risk modeling.

b. (1.5 points)

Identify and briefly describe an aspect of parameter risk introduced by incorporating each of the three lines of business into the insurer's existing ERM model. Use a different type of parameter risk for each line of business.

c. (0.5 point)

Explain why parameter risk may be more significant for large insurers than small insurers.

d. (0.25 point)

Briefly describe how parameter risk can be reduced.

CONTINUED ON NEXT PAGE

23. (2.75 points)

A multiline insurance company is considering different reinsurance options. The following table contains the cumulative probability distributions for net premium minus net losses under three scenarios: BARE (no reinsurance), the current reinsurance structure, and the alternative reinsurance structure.

Probability	BARE	Current	Alternative
0.00%	-217,911,928	-196,110,272	-154,691,590
0.25%	-71,606,742	-53,319,764	-52,785,091
0.50%	-50,326,877	-31,517,432	-26,643,103
1.00%	-31,241,388	-14,127,673	-11,094,195
2.00%	-17,530,205	-5,375,766	-6,715,733
4.00%	-8,476,413	-2,672,775	-4,229,923
8.00%	-2,252,408	-1,431,366	-2,746,629
10.00%	-559,293	-1,084,345	-2,028,415
20.00%	3,431,549	1,100,974	1,980,256
25.00%	4,197,741	1,929,228	2,993,689
50.00%	5,519,858	3,043,212	4,453,299

The following table shows the ceded premium and expected recoveries under each reinsurance structure after reinstatement:

	Ceded Premium	Expected Recoveries
Current	4,307,000	2,632,000
Alternative	2,700,000	1,676,000

a. (1.75 points)

Construct a cost/benefit diagram at each of the following return periods:

i. 1-in-10 years
ii. 1-in-25 years
iii. 1-in-100 years
iv. 1-in-200 years

CONTINUED ON NEXT PAGE

(23 continued)

b. (0.75 point)

Recommend a reinsurance structure for the company to implement utilizing the results in part a. above.

c. (0.25 point)

The model that produced the loss distributions above used a Frank copula for correlating lines of business for clash and accumulation events. Briefly describe a possible improvement to the model.

CONTINUED ON NEXT PAGE

24. (2.75 points)

An insurance company is setting planned written premium volume and loss ratios by line of business for the upcoming year.

a. (1 point)

Briefly discuss two potential shortcomings of a traditional unilateral planning approach in which one version of “the plan” is set.

b. (0.75 point)

Explain how scenario planning could be used in this situation.

c. (1 point)

Describe two advantages to using scenario planning over a traditional unilateral planning approach.

CONTINUED ON NEXT PAGE

25. (1.75 points)

a. (0.5 point)

Describe a behavioral approach to modeling the underwriting cycle.

b. (1.25 points)

Graph a supply and demand curve showing how an industry-wide capital infusion would shift the curves. Briefly describe the rationale behind the shifts.

END OF EXAMINATION

Exam 7
Estimation of Policy Liabilities, Insurance Company Valuation, and Enterprise Risk Management

May 4, 2017

POINT VALUE OF QUESTIONS

QUESTION	VALUE OF QUESTON	SUB-PART OF QUESTION (a)	(b)	(c)	(d)	(e)	(f)	(g)
1	2.00	2.00						
2	1.75	1.75						
3	2.00	1.00	1.00					
4	1.50	1.50						
5	3.00	1.50	1.00	0.50				
6	2.75	2.00	0.75					
7	2.25	0.50	1.75					
8	3.75	0.50	0.75	0.50	1.00	1.00		
9	2.25	2.25						
10	2.00	1.00	1.00					
11	2.50	2.00	0.50					
12	2.00	1.00	1.00					
13	3.00	1.00	1.00	1.00				
14	1.50	1.50						
15	1.50	0.50	0.50	0.50				
16	2.00	1.00	0.50	0.50				
17	1.00	1.00						
18	2.00	0.50	0.25	0.25	0.50	0.50		
19	3.75	0.25	1.75	1.25	0.50			
20	1.25	0.75	0.50					
21	2.00	1.00	1.00					
22	2.50	0.25	1.50	0.50	0.25			
23	2.75	1.75	0.75	0.25				
24	2.75	1.00	0.75	1.00				
25	1.75	0.50	1.25					
TOTAL	55.50							

EXAM 7 SPRING 2017 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 may result in the deduction of points where the calculations cannot be followed or are not sufficiently supported.
- Candidates should justify all selections when prompted to do so. For example, if the candidate selects an all year average and the question prompts a justification of all selections, a brief explanation should be provided for the reasoning behind this selection. Candidates should note that a restatement of a numerical selection in words is not a justification.
- Incorrect responses in one part of a question did not preclude candidates from receiving credit for correct work on subsequent parts of the question that depended upon that response.
- Candidates should try to be cognizant of the way an exam question is worded. They must look for key words such as "briefly" or "fully" within the problem. We refer candidates to the Future Fellows article from December 2009 entitled "The Importance of Adverbs" for additional information on this topic.
- Some candidates provided lengthy responses to a "briefly describe" question, which does not provide extra credit and only takes up additional time during the exam.
- Candidates should note that the sample answers provided in the examiner's report are not an exhaustive representation of all responses given credit during grading, but rather the most common correct responses.
- In cases where a given number of items were requested (e.g., "three reasons" or "two scenarios"), the examiner's report often provides more sample answers than the requested number. The additional responses are provided for educational value, and would not have resulted in any additional credit for candidates who provided more than the requested number of responses. Candidates are reminded that, per the instructions to the exam, when a specific number of items is requested, only the items adding up to that number will be graded (i.e., if two items are requested and three are provided, only the first two are graded).
- It should be noted that all exam questions have been written and graded based on information included in materials that have been directly referenced in the official syllabus, which is located on the CAS website. The CAS takes no responsibility for the content of supplementary study materials and/or manuals produced by outside corporations and/or individuals which are not directly referenced in the official syllabus.

EXAM STATISTICS:

- Number of Candidates: 829

EXAM 7 SPRING 2017 SAMPLE ANSWERS AND EXAMINER'S REPORT

- Available Points: 55.5
- Passing Score: 42
- Number of Passing Candidates: 399
- Raw Pass Ratio: 48.13
- Effective Pass Ratio: 49.63

EXAM 7 SPRING 2017 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 1	
TOTAL POINT VALUE: 2	LEARNING OBJECTIVE(S): A1
SAMPLE ANSWERS	

Sample 1

$$m = \frac{\sum \text{Incremental Loss}}{\sum \text{Premium}}$$

$R^{coll} =$ 0.711 * q * EP

$R^{Ind} =$ (q/p) * Cum. Loss

$R^{GB} =$ p * R^{ind} + q + R^{Coll}

$Z^* =$ p /(p + √p)

$R^* =$ $Z^*(R^{ind}) + (1-Z^*)R^{Coll}$

k	m	p	q	R^{Coll}	R^{ind}	R^{GB}	Z^*	R^*
1	0.522	1.000	0.000	0	0	0		0
2	0.162	0.962	0.038	32,692	33,181	33,162	0.495	32,929
3	0.027	0.734	0.266	251,727	308,038	293,059	0.461	277,580
	0.711							

$$P_2 = \frac{.711 - .027}{0.711}$$

	U^{Coll}	U^{ind}	U^{GB}	U^*
14	614,250	614,250	614,250	614,250
15	872,692	873,181	873,162	872,929
16	1,101,727	1,158,038	1,143,059	1,127,580

Sample 2

M_1 = (450 + 600+ 850)/(1100 + 1210 + 1331) = 0.5218
M_2 = (135 + 240)/(1100 + 1210) = 0.1623
M_3 = (29.25)/(1100) = 0.0266
∑M = 0.7107
P_{2016} = 0.5218/.7107 = 0.7342
P_{2015} = (0.5218 + 0.1623) /.7107 = 0.9626
P_{2014} = 1.000

q_{2016} = 1 – 0.7342 = 0.2658
q_{2015} = 1 – 0.9626 = 0.0374
q_{2014} = 0.0000

Part (i) Collective Method
Ultimate = c_k + EP_k * ELR * q_k
2014 = 614,250 + 1,100,000 * 0.7107 * 0 = 614,250
2015 = 840,000 + 1,210,000 * 0.7107 * 0.0374 = 872,162
2016 = 850,000 + 1,331,000 * 0.7107 * 0.2658 = 1,101,431

Part (ii) Individual Method
Ultimate = c_k/p_k
2014 = 614,250/1.0000 = 614,250
2015 = 840,000/0.9626 = 872,637
2016 = 850,000/0.7342 = 1,157,723

Part (iii) Benktander Method
Ultimate = $(1-q_k^2)*U_{ind} + (q_k^2)*U_0$; U_0 = EP * ELR
2014 = 614,250
2015 = $(1- 0.0374^2)$ * 872,637 + (0.0374^2) * 1,210,000 * 0.7107 = 872,619
2016 = $(1- 0.2658^2)$ * 1,157,723 + (0.2658^2) * 1,331,000 * 0.7107 = 1,142,760

Part (iv) Optimal Method
Z = p/(p+ sqrt(p)) ; 2014 = 0.500; 2015 = 0.495; 2016 = 0.461
Ultimate = $Z*U_{ind} + (1- Z) * U_{collective}$
2014 = 614,250
2015 = (0.495) * 872,637 + (1-0.495) * 872,162 = 872,397
2016 = (0.461) * 1,157,723 + (1 – 0.461) * 1,101,431 = 1,127,381

EXAMINER'S REPORT

Candidates were expected to apply the basic mechanics of four credibility claims reserving methods.

Common errors include:

- Not including ultimate losses in the final answer.
- Applying the complement of credibility in both the Benktander and Optimal methods to the individual loss ratio method rather than the collective loss ratio method.
- Deriving loss development factors directly from the reported losses rather than through incremental loss ratios.

QUESTION 2	
TOTAL POINT VALUE: 1.75	LEARNING OBJECTIVE(S): A1A, A1B

SAMPLE ANSWERS

Sample 1

Need 2013 ultimate first:
X bar = 1/3*(0.37+0.442+0.57) = 0.4607
Y bar = 1/3*1.15*(0.37+0.48+0.592) = 0.5528
XY bar = 1/3*(0.37*1.15*0.37+...) = 0.2632
X^2 bar = 1/3*(0.37^2+...) = 0.2191
b = (XY bar - X bar * Y bar) / (X^2 bar - (X bar) ^2)) = 1.2435
a = Y bar - b * X bar = -0.0201
Since a < 0, using link ratio method instead
2013 ultimate = 0.21 * 1.15 * (0.37+0.48+0.592)/(0.37+0.442+0.57) = 0.2520

Calculate 2014 ultimate
X bar = 1/4*(0.157+0.25+0.4+0.222) = 0.2573
Y bar = 1/4*(0.37*1.15+0.48*1.15+0.592*1.15+0.2520) = 0.4776
XY bar = 1/4*(0.157*(0.37*1.15)+...) = 0.1333
X^2 bar = 1/4*(0.157^2+...) = 0.0741
b = (XY bar - X bar * Y bar) / (X^2 bar - (X bar) ^2)) = 1.3187
a = Y bar - b * X bar = 0.1383
2014 ultimate = a + b * 0.167 = 0.359

Sample 2

AY | Ult L/R
10 | 0.4255 = 0.37*1.15
11 | 0.552 = 0.48*1.15
12 | 0.6808 = 0.592*1.15
b = (XY bar - X bar * Y bar) / (X^2 bar - (X bar) ^2))
Y bar = a + b*X bar

2013 Ult L/R:
X bar = (1.37 + 0.442 + 0.57)/3 = 0.4607
Y bar = (0.4255 + ... + 0.6808)/3 = 0.5528
XY bar = (0.37*0.4255 + ... + 0.57*0.6808)/3 = 0.2632
X^2 bar = (0.37^2 + ... + 0.57^2)/3 = 0.2191
b = 1.244 a = -0.02
Even though a negative "a" value could lead to impractical y values, I will use Least Squares since the problem says to, even though CL maybe more appropriate.
AY 2013 Ult L/R = 1.244*0.21 - 0.02 = 0.2412

AY 2014 Ult L/R:
X bar = (0.157 + ... + 0.222)/4 = 0.2573
Y bar = 0.4255 + ... + 0.2412)/4 = 0.4749
XY bar = (0.157*0.4255 + ...)/4 = 0.1327

X^2 bar = (0.157^2 + ... + 0.222^2)/4 = 0.0741 AY 2014 Ult L/R = 1.3307*0.167 + 0.1325 = 0.335
EXAMINER'S REPORT
Candidates were expected to be aware that they cannot use a negative «a» parameter, because this could result in negative loss ratio. Common errors include: • Using a negative «a» parameter, without mentioning that the chain ladder method should be used instead. • Not using as much data as possible in the calculation. This includes the 2013 data at 48 months.

QUESTION 3	
TOTAL POINT VALUE: 2	LEARNING OBJECTIVE(S): A2
SAMPLE ANSWERS	

Part a: 1 point

Sample 1

As variance is constant

$$f_{12-24} = \frac{(1000 * 1950 + 1200 * 2650 + \cdots + 2000 * 4100)}{(1000^2 + 1200^2 + \cdots + 2000^2)}$$

$$f_{12-24} = 2.06$$

Sample 2

Var proportional to 1 -> Cik^2 weighted factor

$$f_{12-24} = \frac{\left(1000^2 * \left(\frac{1950}{1000}\right) + 1200^2 * \left(\frac{2650}{1200}\right) + \cdots + 2000^2 * \left(\frac{4100}{2000}\right)\right)}{(1000^2 + 1200^2 + \cdots + 2000^2)}$$

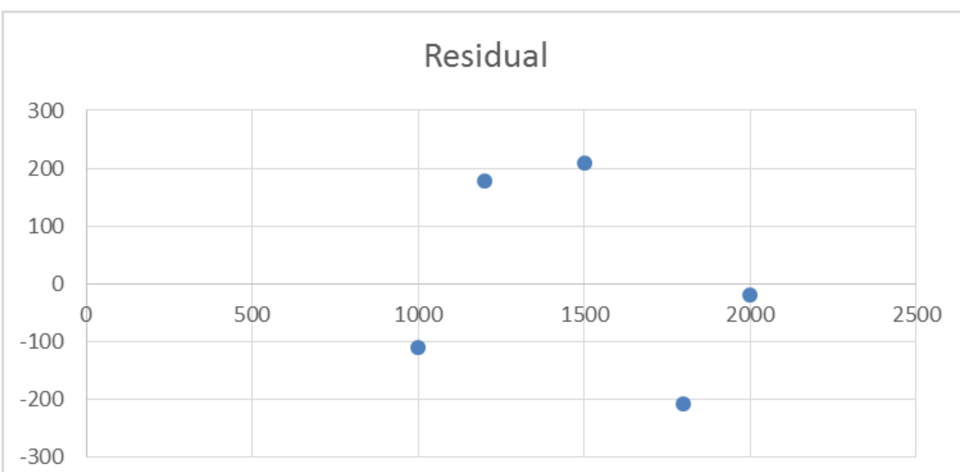
$$f_{12-24} = 2.060$$

Part b: 1 point

Sample 1

Residuals = $c_{i,k+1} - c_{i,k} * f_{k0}$

Accident Year	Loss at 12 months	Expected Loss at 24 months	Actual Loss at 24 months	Residual
2011	1000	1000*2.060 = 2060	1950	1950 – 2060 = -110
2012	1200	2472	2650	178
2013	1800	3709	3500	-209
2014	1500	3091	3300	209
2015	2000	4121	4100	-21



Sample Interpretation 1
Residuals are randomly scattered around zero so the variance assumption is reasonable.

Sample Interpretation 2
Since the residuals are randomly scattered around zero with no trend or change in magnitude, this variance assumption seems reasonable.

EXAMINER'S REPORT

Candidates were expected to understand the relationship between (a) variance assumptions which diverged from the original chain ladder assumptions given in Mack (1994) and (b) methods of calculating loss development factors given the alternate variance assumptions.

Candidates were also expected to understand how to calculate residuals given alternate variance assumptions and how to interpret the results of those residual calculations in order to determine how well the given model fit the data.

Part a

Candidates were expected to understand that the variance assumption stated in the problem (constant variance) differed from the original Mack (1994) chain ladder assumptions. Candidates were expected to apply the correct formula to calculate the loss development factor from 12-24 months, given the alternate variance assumption.

A common error was applying the incorrect formula given the variance assumption stated in the problem

Part b

Candidates were expected to calculate the residuals by accident year given the variance assumption stated in the problem. Candidates were also expected to understand how to plot the residuals graphically and interpret the results to determine if the stated variance assumption was reasonable.

Common errors include:

- Using an incorrect formula to calculate residuals given the development factor calculation in Part a.
- Incorrect labeling on the x-axis of the graph (years, cumulative losses at 24 months, etc.)
- Not giving an interpretation for the residuals – some candidates only stated what the residual plot looked like without giving an interpretation of the results

QUESTION 4

TOTAL POINT VALUE: 1.5	**LEARNING OBJECTIVE(S): A2, A3**

SAMPLE ANSWERS

Sample 1

AY	**Av Age**	**G(x)**	**Used Up Premium**	**AY LR**
			=G(x) * OLP	=Rpt Loss / Used up Prem
2012	54	0.5346	534.6	0.7482
2013	42	0.4222	548.86	0.8199
2014	30	0.2851	456.16	0.8769
2015	18	0.1372	260.68	0.9590
2016	6	0.0215	47.3	1.0571

The loss ratio is increasing as AYs get less mature. They are not constant; using a constant ELR does not seem appropriate.

Sample 2

AY	**Age**	**Avg Age**	**G(x)**	**LDF**	**Ult (000)**	**LR**
2012	60	54	0.53	1.887	754.8	0.755
2013	48	42	0.42	2.381	1,071.45	0.824
2014	36	30	0.29	3.448	1,379.2	0.862
2015	24	18	0.14	7.143	1,785.75	0.940
2016	12	6	0.02	50	2,500	1.136

AY 13 Sample Calcs
Avg Age = 48 – 6 = 42
$G(x) = 42^{1.8} / (42^{1.8} + 50^{1.8}) = 0.42$
LDF = 1 / 0.42 = 2.381
Ult = 450 x 2.381 = 1,071.45
LR = 1,071.45 / 1300 = 0.824

Conclude that ultimate loss ratios are increasing over time (not constant across AYs).

Sample 3

AY	**On-level Prem**	**Reported Loss**	**Avg Age**	**G(x)**	**<u>Rep loss</u> G(x)*EP**
12	1M	400k	54	0.535	0.748
13	1.3M	450k	42	0.422	0.820
14	1.6M	400k	30	0.285	0.877
15	1.9M	250k	18	0.137	0.959
16	2.2M	50k	6	0.022	1.056

Total ELR = sum (Reported Loss) / sum (Prem * G(x)) = 1550/1847.5 = 83.9%

Loss ratio by year is not constant – ranges from 74.8% to 105.6%. The overall ELR is 83.9% which will not provide appropriate IBNR for those high/low years. Overestimate in low LR years and underestimate in high LR years.

Sample 4

I will assume the LDF method is used

AY	X	G(x)	LDF = $G(x_t)/G(x)$	Ult LR
2012	60 – 6 = 54	$54^{1.8} / (54^{1.8} + 50^{1.8})$ = 0.535	0.815/0.535 = 1.523	400x1.523/1000 = 60.9%
2013	42	0.422	1.931	66.8%
2014	30	0.285	2.860	71.5%
2015	18	0.137	5.949	78.3%
2016	6	0.022	37.045	84.2%

Testing twice the last age for truncation: $G(x_t)$ = G(2*60 – 6) = G(114) = 0.815. This is significantly lower than 1.0 so the curve should be truncated at $G(x_t)$ = G(114).

The ultimate expected LRs are increasing with the AY, so there is not expected LR constancy.

Sample 5

AY	X	G(x)	Used-up Prem	Expected Losses	Diff b/w Actual & Expected Losses
	avg age		***G(x)*Prem***	***0.839*G(x)*Prem***	
2012	54	0.535	535	449	400 – 449 = -49
2013	42	0.422	549	460	-10
2014	30	0.285	456	383	17
2015	18	0.137	260	218	32
2016	6	0.022	48	41	9

A constant ELR likely not appropriate, as actual LR tended to increase over AYs, and is not constant.

Sample 6

X	G(x)
54	0.535
42	0.422
30	0.285
18	0.137
6	0.022

$$\text{ELR} = \frac{400 + 450 + 400 + 250 + 50}{1000(0.535)+1300(0.422)+\ldots+2200(0.022)} = 0.839$$

Expected Loss = (Prem)(ELR)(G(x))

Resid = (A – E) / $E^{0.5}$

AY	Exp Loss	Act Loss	Resid
2012	1000(0.839)(0.535) =	400	-2.31

	449		
2013	1300(0.839)(0.422) = 460	450	-0.48
2014	1600(0.839)(0.285) = 382	400	0.89
2015	1900(0.839)(0.137) = 218	250	2.14
2016	2200(0.839)(0.022) = 41	50	1.47

Since the resid appear to increase with time, we do NOT observe LR constancy across AY.

EXAMINER'S REPORT

Candidates were expected to know how to calculate G(x) and translate that into either expected ultimate losses or used up premium, and then compare AYs using either a loss ratio or residual approach to verify the constancy of the expected loss ratio.

The most common error was using a Cape Cod approach. Candidates were expected to realize that they were being asked to verify if the underlying expected loss ratio was appropriate, and therefore should not use that expected loss ratio in their calculation of ultimate loss ratio by accident year.

Additionally, some candidates spent time calculating whether the G(x) values should be truncated. Because the question was asking to look at the trend of the ultimate loss ratios, a candidate who truncated the G(x) values spent time adjusting all G(x) values (and therefore the ultimate loss ratios) by the same value, which had no impact on the final observation about the trend of the ultimate loss ratios.

QUESTION 5	
TOTAL POINT VALUE: 3	LEARNING OBJECTIVE(S): A2

SAMPLE ANSWERS

Part a: 1.5 points

Sample 1

AY	Avg Age	G(X)	CC Reserve = (1-G(x))*ELR*Prem
2014	30	.739	67,986
2015	18	.568	105,462
2016	6	.202	233,694
Total			407,106

$$ELR = \frac{210{,}000 + 130{,}000 + 50{,}000}{400{,}000(.739) + 375{,}000(.568) + 450{,}000\,(.202)} = 0.651$$

Process Variance = 3,000 * 407,106
Parameter Variance = 175,000 ^2
Total Std Dev = $\sqrt{(Proc\ Var + Param\ Var)}$ = 178,456

Sample 2

AY	Avg Age	G(X)	CC Reserve = (G(66)-G(x))*ELR*Prem
2014	30	.7388	42,529
2015	18	.5679	81,573
2016	6	.2019	205,058
Total			329,161

Truncation = G(66) = 0.9022

$$ELR = \frac{210{,}000 + 130{,}000 + 50{,}000}{400{,}000(.7388) + 375{,}000(.5679) + 450{,}000\,(.2019)} = 0.6507$$

Total Std Dev = $\sqrt{(3{,}000 * 329{,}161 + 175{,}000\ \hat{}2)}$ = 177,799

Part b: 1 point

Sample 1

AY	CL Res = Pd/G(X) - Pd	Z = G(X)	Cred Res = Z * CL Res + (1-G(X))* CC Res
2014	74,246	.739	72,611
2015	98,894	.568	101,716
2016	197,642	.202	226,415
			400,742

Sample 2

CL Res = Paid * (G(66)/(G(x) – 1)

AY	CL Res	Z = G(66)/G(X)	Cred Res = Z * CL Res + (1-G(X))* CC Res

2014	46,445	.819	45,736
2015	76,526	.629	78,398
2016	173,427	.224	197,973
			322,108

Part c: 0.5 point

Sample 1

Weibull growth curve $G(x) = 1 - e^{-\left(\frac{x}{\theta}\right)^{\omega}}$ has a lighter tail, so development is completed more quickly which is more appropriate for a short tail LOB

Sample 2

For a short-tailed line of business, the growth curve can be truncated so that it will not further develop after a certain period.

EXAMINER'S REPORT

Candidates were expected to demonstrate knowledge of the Cape Cod reserve method, including the calculation of the standard deviation of the reserves and relationship of credibility to the Benktander method.

Part a

Candidates were expected to calculate the Cape Cod reserve and the standard deviation of those loss reserves.

A common error was calculating the ELR reserve by year instead of the Cape Cod reserve.

Part b

Candidates were expected to calculate the chain ladder reserves and credibility weight those reserves by accident year with the Cape Code reserves.

Common errors include:

- Using an incorrect credibility formula (squaring the credibility factor or multiplying by the ELR)
- Swapping the credibility applied to each reserve
- Using something other than the chain ladder or Cape Cod loss reserves as stated.

Part c

Candidates were expected to identify a different growth and describe why it is more appropriate for a short tailed line of business.

Common errors include:

- Listing a different curve without explanation.
- Selecting different parameters of the log-logistic growth curve provided that were not determined by maximum likelihood.
- Incorrectly identifying the Weibull growth function as exponential.

QUESTION 6

TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE(S): A3**

SAMPLE ANSWERS

Part a: 2 points

<u>*Sample 1*</u>

36-48 LDF = 1.089
48-60 LDF = 1.048 -> 36-ult = 1.141

R_3 = 2750 x (1.141 – 1) = 387.75 ($000)   Assume se($R_3$) = 52.33 is also in ($000)

$$\sigma^2 = \ln(1 + \frac{se(R_3)^2}{{R_3}^2}) = 0.018$$

$\mu = \ln(R_3) - \sigma^2/2$ = 5.951

80 C.I. ($e^{5.951 \pm 1.28\sqrt{.018}}$) -> (323.52, 456.11) ($000)

<u>*Sample 2*</u>

R_3= R for AY 2014

LDF 36-48= (1050+2000)/(950+1850) = 1.0893
LDF 48-60 = (1100)/1050 = 1.0476
CLDF 36-ult = 1.1412

R_3= 2750K(1.1412-1) = 388180

For lognormal distribution: σ^2= ln(1 + (s.e.(R) / R)^2)
= ln(1 + (52.33 / 388180)^2)
=0.000000018

80% CI for R_3 = R_3 e^(+/- 1.28(σ) - .5(σ^2))
= (388113, 388247)

Part b: 0.75 point

	36-48	48-60
2012	1.105	1.048
2013	1.081	

Maximum bound is (1.105 x 1.048) x 2750 = 3184.61

Minimum bound is (1.081 x 1.048) x 2750 = 3115.44

Interval is (3115.44, 3184.61)

EXAMINER'S REPORT

Candidates were expected to demonstrate knowledge of the simulation of parameter percentiles

and unpaid claims percentiles when models assume a distribution of residuals fit by MLE.
Part a
Candidates were expected to construct the 80% confidence interval for R_3 based on the lognormal distribution mu and sigma. Common errors include: • Confusing the standard error of R_3 with sigma • Not providing a final numerical answer • Using the wrong formula for the confidence interval • Using the wrong LDF to calculate the confidence interval • Not plugging in numbers to the confidence interval formula correctly • Assuming a normal distribution for R_3 • Confusing R for C • Using the reserves from all years as R, rather than just AY 2014
Part b
Candidates were expected to use the minimum and maximum age-to-age development factors to calculate a confidence interval for AY 2014 ultimate losses. Common errors include: • Providing the confidence interval for the reserves instead of the ultimates • Using the wrong formula for the confidence interval • Using the paid loss number from a year other than the year specified in the question • Adding 2750 to the final answer from a

QUESTION 7

TOTAL POINT VALUE: 2.25	**LEARNING OBJECTIVE(S): A4**

SAMPLE ANSWERS

Part a: 0.5 point

Sample 1

LDF(24-Ult) = (3348 / 2465) * [(2465 + 2747) / (1354 + 1535)] = 2.4503

Sample 2

LDF (24-36) = (2465 + 2747) / (1354 + 1535) = 1.804
LDF (36-48) = 3348 / 2465 = 1.358
LDF (24-Ult) = 1.804 * 1.358 = 2.450

Part b: 1.75 points

Sample 1

Adjust triangle to basic limit

AY	24	36	48
2013	1354 * (119/110) = 1464.78	2465 * (210/215) = 2407.67	3348 * (244/255) = 3203.58
2014	1535 * (119/115) = 1588.39	2747 * (210/214) = 2695.65	

LDF (24-36) = (2407.67 + 2695.65) / (1464.78 + 1588.39) = 1.6715
LDF (36-48) = 3203.58 / 2407.67 = 1.3306
LDF (24-Ult) = 1.6715 * 1.3306 = 2.2240

Bring to $1m limit
= 2.2240 * [(281/244) / (117/119)] = 2.6050

EXAMINER'S REPORT

Candidates were expected to understand methods for estimating unpaid claims in a deductible layer, excess of a threshold, and excess of retention but bounded by a limit. Candidates were also expected to understand the interrelationships between parameters and development patterns for forecasting deductible, unlimited excess, layer excess and total claims.

Part a

Candidates were expected to calculate unadjusted age-to-age and age-to-ult loss development factors.

Candidates generally did well on this question.

Part b

Candidates were expected to calculate the cumulative reported loss triangle at accident year 2016 cost level and basic limit. Once calculated, then the incremental and cumulative LDFs at the basic limit and accident year 2016 cost level could be computed. Finally, the volume weighted average LDFs at limit of triangle and historical cost levels could be computed.

Common errors include:

- Using the incorrect triangle when computing the cumulative reported loss triangle at AY 2016 cost level and basic limit.
- Stopping at the cumulative volume weighted LDF at basic limit at AY 2016 cost level and

not continuing with the last step of calculating the volume weighted LDF at limit of triangle and historical cost level
- Using 2014 or 2016 as the 24 month LEV instead of the 2015 year.

QUESTION 8	
TOTAL POINT VALUE: 3.75	LEARNING OBJECTIVE(S): A5, A8

SAMPLE ANSWERS

Part a: 0.5 point

Sample 1

A score of 1 would indicate worst practice. A possible scenario for this score might include:

- highly summarized reports with little/no detail
- mislabeled or poorly identified data
- errors in calculations
- missing data without explanation clearly given and/or
- irregular, sporadic, or missing reports (for example, no January report given)

Sample 2

Very little or infrequent communication between actuarial team and claim department

- Information not up to date
- poor timeliness and reliability of information

Sample 3

Data is on an extreme lag, sometimes unavailable, and audits regularly find incorrect and missing data which isn't accounted for

Part b: 0.75 point

A = Parameter selection error
B = Data error
C = Specification error
D = Data error
E = Parameter selection error
F = Specification error

Part c: 0.5 point

Sample 1

Home Avg BSC = (5*3 + 2*2 + 3*5 + 1*2 + 4*3 + 3*5)/(3 + 2 + 5 + 2 + 3 + 5) = 3.15

Auto Avg BSC = (2*5 + 2*3 + 5*2 + 3*3 + 1*5 + 5*2)/(5 + 3 + 2 + 3 + 5 + 2) = 2.5

Sample 2

Home:
Specification = (3+3)/2 = 3
Parameter Selection = (5+4)/2 = 4.5
Data = (2+1)/2 = 1.5

Overall = [5(3) + 3(4.5) + 2(1.5)] / (5+3+2) = 3.15

Auto:
Specification = (5+5)/2 = 5
Parameter Selection = (2+1)/2 = 1.5
Data = (2+3)/2 = 2.5

Overall = [2(5) + 5(1.5) + 3(2.5)] / (2+5+3) = 2.5

Part d: 1 point

Sample 1

Home CoV = 6%
Auto CoV = 5%

w (home) = 45/50 = .9
w (auto) = 5/50 = .1

Internal CoV = (.9 ^ 2 * .06 ^ 2 * .1^2 * .05^2 + .4*2*.9*.1*.06*.05)^0.5 = 0.56

Sample 2

ϕ (Home) = 6.0%
ϕ (Auto) = 5.0%
w (Home) = 45/50 = .9
w (Auto) = 5/50 = .1

$$\Sigma = \begin{pmatrix} 1.0 & .40 \\ .40 & 1.0 \end{pmatrix}$$

Using Matrix Multiplication
(ϕw) = (.054 .055)
(ϕw) $\Sigma = (.056\ .0266)$

ϕ^2 (Internal) = (ϕw) Σ (ϕw)
$= .054 * .056 + .005 * .0266 = .003157$
ϕ (Internal) = .0562

Part e: 1 point

Sample 1

Risk Margin = $\phi z \mu = (.056$^2 + .04^2 + .08^2)^0.5 * .842 * (50M) = $4.44

EXAMINER'S REPORT

Candidates were expected to be able to demonstrate their knowledge of various sources of risk and uncertainty, and how scores are determined in a Balanced Scorecard Assessment. Candidates were also expected to calculate risk margins that consider these sources of risk and uncertainty.

Part a

Candidates were expected to identify a scenario that has a higher risk potential and is related to the Data Error risk component.

Common errors include:

- Identifying a risk that was not a Data Error risk, such as risk of adverse development or cat risk.
- Identifying a scenario that has a lower risk potential, such as data that was provided in an accurate or timely manner.
- Defining Data Error risk without identifying a scenario that would result in a higher risk

potential.

Part b

Candidates were expected to classify potential risk indicators into three possible risk components.

Common errors include:

- Categorizing item b (Knowledge of past processes affecting predictors) as a Parameter Selection Error.
- Categorizing item b (Knowledge of past processes affecting predictors) as a Specification Error.

Part c

Candidates were expected to calculate balanced scorecard assessment scores, based on their selections in part b., the home and auto weights for each of the 3 risk components, and the home and auto scores for each of the 6 potential risk indicators.

Common errors include:

- Using separate CoV lookups for each of the 3 risk components and calculating their weighted average.
- Using a weight of (5+3+2) in the denominator after having selected more than 2 of any risk component in part b. or using the same weights for both auto and home.

Part d

Candidates were expected to look up the home and auto CoVs based on the balanced scorecard assessment scores from part c., calculate the home and auto weights based on outstanding claims liabilities, and compute the internal systemic risk CoV.

Common errors include:

- Not using the balanced scorecard assessment scores from part c. to look up the correct CoV from the table.
- Using 50/50 weighting between home and auto instead of 90/10.
- Not squaring the w(i)*Cov(i) terms in the internal systemic risk calculation.
- Omitting the 2*ρ*w(home)*w(auto)*Cov(home)*Cov(auto) in the internal systemic risk calculation.
- Not multiplying the □*w(home)*w(auto)*Cov(home)*Cov(auto) by 2 in the internal systemic risk calculation.
- Not using the square root in the internal systemic risk calculation.

Part e

Candidates were expected to calculate the total insurance liabilities CoV, based on the total independent risk CoV, the external systemic risk CoV, and the internal systemic risk calculation calculated in part d. Candidates were also expected to calculate the risk margin based on the total insurance liabilities CoV, the 80^{th} percentile of the Standard Normal distribution, and the dollar amount of the outstanding claims liabilities.

Common errors include:

- Neglecting to calculate the total insurance liabilities CoV, and instead use the total internal systemic risk coefficient for the calculation of the risk margin.
- Not squaring the terms in the calculation of the total insurance liabilities CoV.

- Not using the square root in the calculation of the total insurance liabilities CoV.
- Not converting the risk margin to dollars.
- Adding $50 million to the risk margin.

QUESTION 9	
TOTAL POINT VALUE: 2.25	LEARNING OBJECTIVE(S): A4
SAMPLE ANSWERS	

Sample 1

LDF_{24-Ult} = 1.309 * 1.114 * 1.043 * 1.019 = 1.55

$LDF_{24-Ult}^{0\ to\ 250{,}000}$ = LDF_{24-Ult} * $\frac{R_{Ult}^{L}}{R_{24}^{L}}$, where RL is at limit 250 000

= 1.55 * 0.94 / 0.97

= 1.502

$R_{24}^{100{,}000\ to\ 250{,}000}$= Limited severity at 100 000 / Limited severity at 250 000

= 0.93 / 0.97

= 0.9588

$R_{Ult}^{100{,}000\ to\ 250{,}000}$=

= 0.85 / 0.94

= 0.9043

$XSLDF_{24-Ult}^{100{,}000\ to\ 250{,}000}$ = $LDF_{24-Ult}^{0\ to\ 250{,}000}$ * (1 - $R_{Ult}^{100{,}000\ to\ 250{,}000}$) / (1 - $R_{24}^{100{,}000\ to\ 250{,}000}$)

= 1.502 * (1 - 0.9043) / (1 - 0.9588)

= 3.488

Reported losses in layer $100k to $250k = 3,675,000 – 3,450,000 = 225,000

By direct development approach,

IBNR = 225,000 * (XSLDF – 1)

= 225,000 * 2.488

= 559,687.5

Sample 2

LDF_{24-Ult}^{Unlim} = 1.309 * 1.114 * 1.043 * 1.019 = 1.550

$LDF_{24-Ult}^{100k-\ 250k}$ = LDF^{Unlim} * (R_{Ult}^{250k} - R_{Ult}^{100k}) / (R_{24}^{250k} - R_{24}^{100k})

=1.550 * $\frac{(0.94-0.85)}{(0.97-0.93)}$ = 3.488

Rept at 24 100k – 250k = 3675k – 3450k = 225,000

Unlimited $IBNR_{2015}$ = 225,000 * (3.488 – 1) = 559,800

Sample 3

Unlimited 24-Ult LDF = 1.309 * 1.114 * 1.043 * 1.019 = 1.55

Limited 100k 24-Ult LDF = LDF * R_{Ult} / R_{24} = 1.55 * 0.85 / 0.93 = 1.4167

Limited 250k 24-Ult LDF = 1.55 * 0.94 / 0.97 = 1.502

Limited 250k 24-Ult LDF = Limited 100k LDF * $R_{24}^{100to250}$ + XSLDF * (1 - $R_{24}^{100to250}$)

1.502 = 1.4167 * ($\frac{0.93}{0.97}$) + XSLDF * ($1 - \frac{0.93}{0.97}$)

XSLDF for Layer between 100k and 250k = 3.485

Reported loss in (100k, 250k) layer = 3,675,000 – 3,450,000 = 250,000

IBNR = 225,000 * (3.485 – 1)
= 559,125

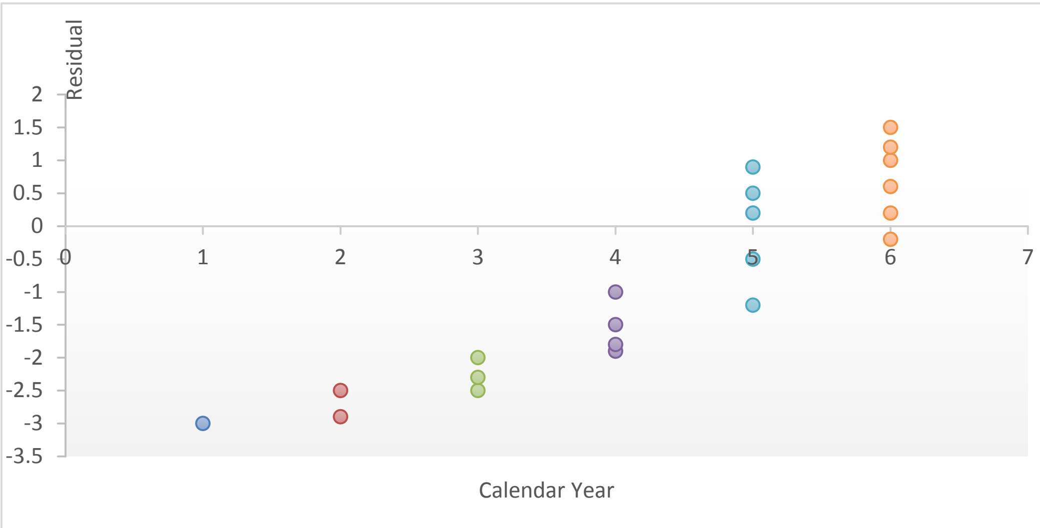
EXAMINER'S REPORT

Candidates were expected to calculate an LDF for losses within a certain layer from unlimited LDF's & severity relativities using Siewert's formula. Then they were to apply this LDF directly to incurred losses to derive IBNR for that layer.

Common errors include:

- Neglecting to calculate the LDF limited to $250k, before applying Siewert's formula to calculate the layer from $100k to $250k
- Not deriving and applying an LDF directly to losses in the layer: they developed the layer limited to $250k and the layer limited to $100k and took the difference
- Using severity relativities for entire excess $100k layer or limited $250k layer, instead of deriving severity relativities for losses specifically between $100k and $250k

QUESTION 10	
TOTAL POINT VALUE: 2	LEARNING OBJECTIVE(S): A9
SAMPLE ANSWERS	
Part a: 1 point	



Sample 1
We are systematically over-predicting at early calendar years and under-predicting at later calendar years, implying there is an increasing (i.e. inflation) effect for which our model is not accounting.

Sample 2
The model overstates losses for older CYs and underestimates losses for recent Cy's indicating a trend (i.e. inflation) not reflected in the model.

Sample 3
Since there is clearly an increasing pattern in the residuals from one CY to the next. This means the expected is overstated in early Cys and understated in recent Cys. This is a sign of CY trend due to inflation.

Part b: 1 point

Sample 1
It shows heteroscedasticity because the variance is not constant across development periods; It is clearly higher (or lower) for 12 & 24 than it is for 36 & 48.

Sample 2
The residual show more (or less) spread at 12 and 24 month compared to 36 and 48 month.

Sample 3
Residuals for ages 12 and 24 are more wider spread than those at age 36 and 48 which means residuals do not have constant variance → heteroscedasticity.

EXAMINER'S REPORT

Candidates were expected to demonstrate the knowledge of testing assumptions underlying the bootstrap model.

Part a

Candidates were expected to construct a plot with labeled axis, zero-line and residuals at each calendar year showing upward trend (downward trend is acceptable if noted there was a deflation). Candidates were expected to describe how the upward trend indicates inflation not captured by the model.

Common errors include:

- Forgetting to label zero line.
- Providing an inappropriate pattern of number of residuals at each calendar year (the number of residuals should be increasing along the CY axis).
- Providing a description of the plot instead of reasoning how the trend indicates missing inflation captured by the model

Part b

Candidates were expected to construct a plot with labeled axis, zero-line and residuals at development age 36 and 48 showing similar dispersion but different with other ages. Candidates were expected to briefly explain how the residuals pattern demonstrated heteroscedasticity.

Common errors include:

- Forgetting to label the zero line.
- Providing an inappropriate number pattern of residuals at each development age (the number of residuals should be decreasing along the development age axis).
- Not plotting residuals at all required ages (12, 24, 36 and 48).
- Misunderstanding the variance concept and how variance is manifested in the plot.

QUESTION 11	
TOTAL POINT VALUE: 2.5	**LEARNING OBJECTIVE(S): A10**

SAMPLE ANSWERS

Part a: 2 points

Sample 1

24 to 36 months:

Z_{ij}= (.667) / (0.01234 * 9.125 + .667) = .856 λ_j = 1.364 $D_{i\,j-1}$ = 9000 M = α / β = 8104

% emerged = .909 -.667 = .242

$E[C_{ij}]$ = .856 * 9000 *.364 + (1-.856) * 8104 * .242 = 3087

36 to 48 months:

Z_{ij}= (.909) / (0.01234 * 9.125 + .909) = .890 λ_j = 1.073 $D_{i\,j-1}$ = 12087

% emerged = .067

$E[C_{ij}]$ = .89 * 12087 *.073 + (1-.89) * 8104 * .067 = 845

3087 + 845 = 3932

Sample 2

Z = (1/CDF) / (φβ + 1/CDF) = 1/1.5 / (9.125(0.1234) + 1/1.5) = .856

$E(C_{2015\ 36})$ = .856(1.364 – 1)(9000) + (1-.856)(1.364-1)(8130.7)(1/1.5) = 3087.4

M = α / β = 100 / .01234 = 8103.7

$C_{2015\ 48}$ = 1/1.1 / (9.125(0.1234) + 1/1.1) = .890

$E(C_{2015\ 48})$ = .890(1.073-1)(9000+3087.4) + (1-.890)(1.073-1)(8103.7)(1/1.1) = 844.5

Total incr. emergence 24-48 mo = 3087.4 + 844.5 = 3931.9

Sample 3

$E[C_{15,\ 24\text{-}48}]$ = (.667 / (.667 + .01234(9.125)) (1.364*1.073 – 1) (9000) +
(1 - .8556) ((1.364*1.073 -1)/ 1.5) (8103.7277) = 3931.3311

Sample 4

E(Incr Loss CL) = 9000(1.5)(.976-.667) = 4171.5

E(Incr Loss prior) = 100/.01234 (.976 - .667) = 2504

Z_{ij} = % reported / φβ + % reported = .667 / (9.125(.01234) +.667) = .856

Expected incremental = .856(4171.5) + (1-.856)(2504) = 3931.4

Part b: 0.5 point

Sample 1

β would have to change. β controls the variance for the prior distribution. If we want an estimate closer to chain ladder, we want a larger variance in the prior distribution so we want a smaller β.

Sample 2

If β is reduced, it means Z gets larger and more weight is put on the CL indications in the Bayesian

model formula.
EXAMINER'S REPORT
Candidates were expected to demonstrate an understanding of both the incremental chain ladder estimates and incremental B-F estimates for IBNR and use credibility weights to estimate 2 years IBNR development. Candidates were also expected to understand the key parameters used in the model.
Part a
Candidates were expected to obtain estimates for IBNR in 2017 and 2018 Common errors include: • Omitting the 36 to 48 month development • Using chain ladder estimate for $C_{2015,36}$ in place of credibility weighted IBNR from the model • Applying incorrect Loss Development factors (Chain Ladder or B-F) • Applying an incorrect percent reported (in the credibility calculation and in the B-F estimate)
Part b
Candidates were expected to show understanding of the model parameters which changed the weights between the chain ladder method and the Bornhuetter-Ferguson method of estimating IBNR. Common errors include: • Indicating the wrong direction for β • Providing direction only for dispersion parameter (φ) - text provides examples of actuary selecting β and refers to φ as a "nuisance parameter" that is solved using maximum likelihood estimates.

QUESTION 12	
TOTAL POINT VALUE: 2	**LEARNING OBJECTIVE(S): A8**

SAMPLE ANSWERS

Part a: 1 point

Sample Responses include any 4 of the following:

- Increasing exposures
- Last diagonal is not a complete year
- First evaluation period is not a complete year
- Missing earlier data in triangle, AY11 at 6 + 18 months and AY12 at 6 months
- High development at AY 2013 age 42 could be an outlier

Part b: 1 point

Sample Responses to the responses in part a. include:

- Should divide claims by exposure and model loss ratios
- Annualize the losses, calculate LDFs and de-annualize results
- Calculate LDFs as normal. Need to estimate AY 2016 losses by dividing in half, to approximate 50% earned in that year
- Do not use those years when calculating volume weighted LDFs
- Exclude outlier from the calculation of the loss development factors and residual calculation, but re-sample the corresponding incremental when re-sampling triangles.

EXAMINER'S REPORT

Candidates were expected to identify data issues and related model adjustments when using the ODP bootstrap model for reserving.

Part a

Candidates were expected to list four problems related to the data provided in the problem in the context of an ODP bootstrap model.

Common errors include:

- Mistaking incomplete data for year 2011 for an outlier
- Not taking the fact the last diagonal is 9 months only into consideration when evaluating outliers (2015 was often identified as an outlier)
- Not taking exposure growth into consideration when evaluating outliers
- Mixing up CY and AY
- Stating that the last diagonal has 3 months of incremental loss data (it has 9 months in AY other than 2016)
- Providing problems that were not in this specific data.

Part b

Candidates were expected to list 4 adjustments to the ODP bootstrap model to address the issue mentioned in part a. The adjustments listed needed to address the issue mentioned in a.

Common errors include:

- Struggling in providing the correct adjustment for the partial first development period and the partial last calendar year.
- Partial first development period: Failure to mention that the adjustment was for the 2016 AY

- Partial first development period: Stating that the final results needed to be multiplied by 2
- Mixing up the adjustments for partial first development period and partial last calendar year
- Partial last calendar year : Removing the last diagonal as a solution
- Partial last calendar year: Failure to mention that the claims in the most recent diagonal needed to be re-adjusted to a partial year after the simulation process
- Providing adjustments for problems that were not present in the data.

QUESTION 13	
TOTAL POINT VALUE: 3	LEARNING OBJECTIVE(S): A9

SAMPLE ANSWERS

Part a: 1 point

Sample 1

The histogram implies that our model is not heavy enough on the tails, since we are seeing far more than 10% of observed values on what should theoretically be the most extreme 10% (low and high) of our model. This would indicate that the model's confidence interval should be wider. However, the histogram is symmetrical, so at least our model appears to be unbiased relative to actual results – the mean (expected value) should be pretty accurate.

Sample 2

The bars for the highest and lowest percentile are taller than the rest. This indicates that the model is light tailed and is underestimating the size of the confidence interval. Since the histogram is symmetric, the model is equally light in both the left and right tails, so the expected value produced by the model is correct.

Sample 3

We want the histogram bars to be level, not so large at the extremes. The expected value is probably ok, but this is not a good model for this process. The model is too light in the tails. This means the model confidence interval is too small.

Part b: 1 point

Sample 1

The backwards S shape indicates the model is heavy tailed and therefore the actual estimates are landing in the lowest + highest deciles less often than predicted. P-P plot appears symmetric indicating the expected value is okay but the variance is overstated. I would expect the min + max in the confidence interval to both more closer to the mean.

Sample 2

There are more observations at the middle percentiles than expected – suggests the model is heavy tailed. It does not appear asymmetrical or biased high or low so the expected value is reasonable. The confidence interval is too wide (large).

Sample 3

It shows that the model has heavy tail. Mean is reasonable = 70 mil. CI was overestimated. The actual results are not that extreme. CI should be (65, 75).

Part c: 1 point

Sample 1

According to the histogram, there are many more observations in the 90th and 100th percentile buckets. Because of this the model is biased low. The model isn't predicting enough higher losses. Because of this, the expected value is too low. There is nothing to indicate that the model is heavy or light tailed, so the confidence interval (other than the expected value being off) seems ok.

Sample 2

Instead of the uniform Freq we expect, Actual values are higher in the right tail than expected, which means our model is biased low, and has a light right-tail. Expected value of model is too low, and upper confidence interval needs to be higher.

Sample 3

The histogram shows that predicted percentiles fall more in the higher percentile than in the middle and lower this indicates that model is biased low. This means that the expected value is not accurate, it should be higher. When expected value changes, confidence interval would change but the model does not indicate that the size of the interval is not accurate.

EXAMINER'S REPORT

Candidates were expected to understand what is implied about the accuracy of the expected value and the size of the confidence interval of a stochastic loss reserving model when the actual observations do not fit the model well.

Part a

Candidates were expected to discuss the points mentioned above when actual observations fall in the lowest and highest percentiles more often than the model predicts (model too light in the tails). The information provided to the candidates was a histogram showing the frequency of observations at each percentile.

Common errors include:

- Talking about predicted values instead of actual values when describing the histogram.
- Not being clear on whether the candidate was talking about the expected value/confidence interval of the predicted or actual distribution.
- Not recognizing the light tailed model situation, often confusing it with the heavy tailed model situation (both tails).

Part b

Candidates were expected to discuss the points mentioned above when actual observations fall in the middle percentiles more often than the model predicts (model too heavy in both tails). The information provided to the candidates was a p-p plot confronting expected and predicted percentiles.

Common errors include:

- Making comments about the model fit i.e. model is not a good fit because it is outside the K-S bands.
- Mixing up predicted and actual values when describing the graph.
- Not being clear on whether the candidate talked about the expected value/confidence interval of the predicted or actual distribution.
- Not recognizing the heavy tailed model situation, often confusing it with the light tailed model situation (both tails) or light left tail and heavy right tail situation.
- For the accuracy of the expected value, the candidates often justified the accuracy by the fact that 50th predicted percentile = 50th expected percentile, which is not

a valid reason without stating the assumptions that both distributions follow a normal distribution (or any distribution where median = mean).

Part c

Candidates were expected to discuss the points mentioned above when actual observations fall in the highest percentiles more often than the model predicts (model too light in the right tail). The information provided to the candidates was a histogram showing the frequency of observations at each percentile.

Common errors include:

- The candidate often mixed up predicted and actual values when describing the graph.
- Not being clear on whether the candidate was talking about the expected value/confidence interval of the predicted or actual distribution.
- Not recognizing the biased low model situation, often confusing it with the biased high model situation (and reverse the expected value/confidence interval implications).
- Mentioning the confidence interval was accurate without justification. This answer was accepted when coupled with a valid justification (ex.: all percentiles except 90th and 100th are uniform).

EXAM 7 SPRING 2017 SAMPLE ANSWERS AND EXAMINER'S REPORT

QUESTION 14	
TOTAL POINT VALUE: 1.5	LEARNING OBJECTIVE(S): 11-13

SAMPLE ANSWERS

Sample 1

- Claim report time lag between data of accident to reporting to reinsurer is much longer.
- Persistent upward development. Cedant tends to reserve at modal values & under reserve ALAE. Claims the hit reinsurance tend to be larger losses then modes.
- Heterogeneity of reporting patterns -> different lines of business, contract type, and underlying product all have different reporting patterns.
- Industry data not very useful -> due to heterogeneity.
- Reports received by reinsurer usually lack important info. Usually, summary reports and inadequate info on individual claims.
- IT system & data coding problems. Usually IT systems cannot keep up with growth of company. Heterogeneous nature of contracts & claims.

Sample 2

- Data lags to reinsurers are longer than those for primary insurers.
- There is persistent upward development of losses for reinsurers.
- Due to heterogeneity of coverages, industry statistics aren't very useful.
- Heterogeneity also causes IT and data issues for reinsurers.
- Reporting patterns can vary by many dimensions like cedant, intermediary, type of contract, attachment points etc.
- Management might not believe actuarial indications since the ratio of reserves to surplus are so high.

Sample 3

- Reinsurers have longer claim report lag since the claim first has to be seen as reportable to the primary insurer then flow through their system to the intermediary, then the reinsurer system.
- Reinsurer sees persistent upward claim development due to the primary insurers who usually understate ULAE or reserve at modal value.
- Reinsurers have reporting patterns that are heterogeneous since reinsurers cover different line of businesses, different limits, etc.
- Reinsurers do not have useful industry statistics due to this heterogeneity.
- Reinsurers report lack important information as sometimes this information is summarized as it is for proportional reinsurance.
- Reinsurers have data coding and IT problem due to heterogeneity and rapid growth where systems cannot keep up.

EXAMINER'S REPORT

Candidates were expected to understand the differences between reinsurers and primary insurers relating to reinsurance and primary reserving methods, impact on assumptions from differences in information available to reinsurers and the underlying business characteristics of reinsurance contracts.

Common errors include:

- Rephrasing reasoning already mentioned.
- Using the word "heteroskedasticity" instead of the word "heterogeneity".

QUESTION 15	
TOTAL POINT VALUE: 1.5	LEARNING OBJECTIVE(S): A11

SAMPLE ANSWERS

Part a: 0.5 point

Sample 1
Reinsurers might add additional reserves on individual claims based on their expertise. Primary insurers have don't need to add additional reserve since they booked the original reserves themselves.

Sample 2
Primary insurer often sets case reserves at modal values, reinsurers would want to increase that to a realistic amount.

Sample 3
Reinsurers tend to be more conservative due to lack of exposure and detailed underlying claims data. There is report lag b/t cedant and reinsures w/ inflation. ACR for reinsurers should be higher.

Sample 4
Additional case reserves on individual claims would be higher for a reinsurer since primary insurer tend to under-reserve ALAE and may set case reserves equal to a modal value.

Sample 5
Will be higher for reinsurer since primary insurer probably only reserve at modal value. Reinsurer will receive the cases that exceed a certain threshold, so they will probably need additional claims reserve.

Part b: 0.5 point

Sample 1
For a primary insurer, the losses haven't been reported yet, but for a reinsurer, it's possible that the loss has been reported to the primary insurer, but not to the reinsurer yet (hasn't reached the threshold). So probably higher for reinsurer.

Sample 2
Reinsurer will have a higher pure IBNR than primary as XOL loss will have a long tail, but most of it will not affect the primary insurer.

Sample 3
Because of limited data, the reinsurer will sometime include IBNR and IBNER in the same IBNR field. It is not so for the primary insurer.

Part c: 0.5 point

Sample 1
Primary insurer doesn't have Risk Load. It is added by reinsurer due to the high risks the reinsurer is exposed to due to the long reporting lag or insufficient information etc.

Sample 2

Losses below the limit will be more stable and predictable than excess losses, the reinsurer will need to carry a higher percentage risk load than the primary to have the same confidence of adequate reserves. Can become a mgmt. issue for reinsurer as the need a higher RSV/SURPLUS ratio.

Sample 3
Risk load would typically be higher for a reinsurer than a primary insurer because there is additional uncertainty for reinsurers due to report lag, heterogeneous claims, limited information, amongst others that could require additional protection from a risk load.

Sample 4
The risk load is likely higher for a reinsurer as they might have greater need for catastrophe protection.

EXAMINER'S REPORT

Candidates were expected to compare and contrast reinsurance and primary reserving procedures.

Part a

Candidates were expected to know the components of a reinsurer's loss reserve.

Common errors include:

- Stating that ACR is more for primary insurer than for reinsurer
- Stating that the process of reserving is different between primary and reinsurer and not stating this component is unique for reinsurer or larger for reinsurer.

Part b

Candidates were expected to know Impact on assumptions from differences in information available to reinsurers

Common errors include:

- Stating that higher IBNR is due to low frequency/high severity for reinsurer
- Stating that higher IBNR is due to inflation/social economic factors for reinsurer

Part c

Candidates were expected to know the components of a reinsurer's loss reserve.

Common errors include:

- Stating that risk load is more for primary insurer than for reinsurer
- Stating that inflation caused higher risk load for reinsurers
- Stating that higher risk load is due to uncertainty/volatility/difficulty to estimate reserves without mentioning specific reasons, only partial credits were granted

QUESTION 16

TOTAL POINT VALUE: 2 | **LEARNING OBJECTIVE: A11, A12, A13**

SAMPLE ANSWERS

Part a: 1 point

Sample 1

Acc. Year	Adj. EP	Report Lag	Used up EP	Reported Loss
2012	5,000	.91	4,550	3,500
2013	5,500	.80	4,400	3,300
2014	6,000	.67	4,620	2,750
2015	6,500	.40	2,600	2,500
2016	7,000	.20	1,400	2,000
Total			16,970	14,050

ELR = 14,050/16,970 = .828

AY 2016 IBNR = Adj. EP * ELR * (1 – Report Lag) = 7000*.828*.8 = 4637

Sample 2

Used-up EP = (5000*.91+5500*.80+6000*.67+6500*.4+7000*.2) = 16,970
Total reported loss = (3500+3300+2750+2500+2000) = 14,050
ELR = 14050/16970 = .828

IBNR for AY 2016 = 7000 * .828 * (1 - .20) = 4637

Part b: 0.5 point

Sample 1

- Advantage: more stable than CL at early maturities where CDF would be highly leveraged and losses volatile
- Disadvantage: need to adjust premiums for rate changes and it can be difficult to obtain accurate on-level EP.

Sample 2

- Advantage: SB uses actual experience, including latest year, to determine the ELR.
- Disadvantage: The rate-level adjustment can be difficult, depending on information available.

Sample 3

- Advantage: calculates the ELR from the data rather than using a selection like the BF method.
- Disadvantage: requires rate level adjusted premium which may be difficult to obtain.

Part c: 0.5 point

Sample 1

I would use a credibility weighted IBNR since CL is highly leveraged but SB and BF are low and don't take the large reported losses for the year into account in their IBNR calculation. It could reflect a change in the level of loss for the year.

Sample 2

AY 2016 has reported losses that are much higher than expected based on older years. We would have to give that some credibility, so I would use some type of credibility-weighted method between the SB and chain ladder. I would give little credibility to the reported losses, especially if it was due to one large claim.

Sample 3

AY	Chain-ladder LR
2012	.77
2013	.75
2014	.69
2015	.96
2016	1.43

For 2017, losses at 2m seem very high looking at chain ladder results. Given that only 20% is assumed reported, it might be better not to rely on the experience using chain ladder. I prefer the Bornhuetter-Ferguson here because this seems like an uncertain year. Since the BF is higher than SB, it is a more conservative choice. The BF a priori ELR might reflect some additional information about this book of business that is not reflected in the SB method.

EXAMINER'S REPORT

Candidates were expected to know the definition, assumptions, calculation procedure and relative advantages for the chain ladder, Bornhuetter-Ferguson and Stanard-Bühlmann reserving methods. Candidates were also expected to be able to apply this knowledge to a given set of data.

Part a

Candidates were expected to know how to calculate the Stanard-Bühlmann method, including the use of adjusted earned premium to calculate the used-up premium, calculation of the expected loss ratio (ELR) and calculation of IBNR.

Common errors include:

- Confusing the SB method with a credibility method.
- Deriving the IBNR by taking the SB indicated ultimate with full adjusted premium and subtracted reported losses to date rather than using the unused premium portion to derive the IBNR.

Part b

Candidates were expected to know the advantages and disadvantages of the Stanard-Bühlmann method.

Common errors include:

- Listing the same issue as an advantage and disadvantage. For example, stating that data was used to compute the ELR as an advantage and stating that the method was not responsive to changes in the data as a disadvantage.
- Commenting that two actuaries would come to the same result using the same data. This is not actually true in all cases. However, if the candidate responded with two actuaries coming up with the same result given the same adjusted premium, then this was a valid

response.
Part c
Candidates were expected to know how to select and justify the choice of a method for establishing the IBNR reserve based on a given set of loss data. Full credit was given for responses that commented both on the choice of method and how some aspect of the data supported this choice. Common errors include: • Stating the relative advantages of the methods without explaining how their recommendations fit the data. • Recommending taking the middle estimate or the average of the two low estimates without justification by some aspect of the data.

QUESTION 17	
TOTAL POINT VALUE: 1	LEARNING OBJECTIVE(S): A14

SAMPLE ANSWERS

Sample 1

%Loss 2nd = $\frac{1}{1.6} = 0.625$

%Loss 3rd = $\frac{1}{1.25} = 0.8$

1-0.8 = 0.2

0.8-0.625 = 0.175

CPDLD 3rd = $\frac{0.4 \times 0.175 + 0.25 \times 0.2}{0.175+0.2} = \frac{0.12}{0.375} = 0.32$

Sample 2

#	PDLD	CDF	% reported	(inc) % emerged
1				
2		1.6	0.625	
3	0.4	1.25	0.8	0.175 = 0.8 – 0.625
4	0.25	1	1	0.2

$CPDLD_3 = \frac{0.4 \times 0.175 + 0.25 \times 0.2}{0.175+0.2} = 0.32$

Sample 3

% of loss reported at 2nd adj. = $\frac{1}{1.6} = 0.625$

% of loss reported at 3rd adj = $\frac{1}{1.25} = 0.8$

Incremental loss reported at 2nd – 3rd adj = 0.175

Incremental loss reported at 3rd – 4th adj = 0.2

$CPDLD_3 = \frac{0.4 \times 0.175 + 0.25 \times 0.2}{0.175+0.2} = 0.32$

EXAMINER'S REPORT

Candidates were expected to demonstrate understanding of the connection between loss reporting pattern PDLD and CPDLD ratios in the context of retrospective rating adjustments.

Candidates were expected to know the formula and apply it using the information given. The key steps are identifying the CPDLD formula, calculating the incremental reporting pattern between the retro adjustments, and correctly calculating the result.

Common errors include:

- Using weights other than incremental percent reported in the solution. Some candidates used the cumulative percent reported or the percent unreported.
- Using PDLD ratios weighted with incremental percent reported from the wrong development period.
- Not knowing the CPDLD formula.

QUESTION 18	
TOTAL POINT VALUE: 2	LEARNING OBJECTIVE(S): A14a
SAMPLE ANSWERS	

Part a: 0.5 point

Sample Responses for Advantages include any of the following:

- Direct method of developing prem as focuses on premium itself
- Responsive to how premiums have developed historically
- As Feldbloom argues, it is more consistent with the way we develop losses
- Easy to calculate and understand

Sample Responses for Disadvantages include any of the following:

- Premium data/adjustments are often delayed around 9 months and since premium depends on losses -> quicker results (less lag) if use losses instead
- Will not pick up any parameter changes that go into the premium such as changes in expenses that impact the basic premium or changes in the tax multiplier
- May be quite volatile especially if the business mix has changed and does not reflect the retrospective rating logic
- If changing contract parameters, the chain latter method will no longer be representative of the expected development

Part b: 0.25 point

Sample Responses include any of the following:

- Assumes constant prem-to-loss development -> not accurate since more and more losses are capped in later adjustments
- Fitzgibbon's method is only based on ultimate losses so if your reporting pattern isn't coming in as expected there is no way to get back on track to estimate future retro premiums accurately
- It calculates a fixed amount of ultimate premium without consideration of the amount of premium actually emerged and booked at last period. So it created a potential large difference and no way to fix it.

Part c: 0.25 point

Sample Responses include any of the following:

- The "y-intercept will be >0 due to fixed expenses, profit, etc to cover
  -> then for each dollar of loss, some will be capped or hit min/max in plan
  -> if slope was 1.0 insured would be paying back for all losses + expenses -> wouldn't make sense
- There are min/max premiums and loss capping in retro rating plans
- Part of losses above maximum and per occurrence limit
  - Minimum above Basic premium in certain plans
  - LCF and tax multiplier effect

Part d: 0.5 point

Sample Responses for Advantages include any of the following:

- Losses develop more quickly than premiums -> get quicker results/estimates
- Based directly on the retro rating formula
- Timeliness: can calculate premium asset as soon as losses are reported and booked and

update each quarter • It is more responsive to the current parameters sold. *Sample Responses for Disadvantages include any of the following:* • Parameters to use in formulas may be difficult to estimate if book of business has been changing • Can be difficult to estimate the parameters such as the basic premium and tax multipliers that go into the retro rating formula • There could be a bias due to application of average parameters in the PDLD formula
Part e: 0.5 point
Sample Responses include any of the following: • PDLD slopes start steep and then become more and more shallow -> recognizing more and more losses capped in later adjustments -> PDLD -> this is an improved (more accurate process than Fitzgibbons • The PDLD method recognizes that premium responsiveness to losses decreases with each retro adjustment as more losses become capped and the min/max premiums get applied, while Fitzgibbon's method is only based on premium responsiveness to ultimate losses, not at each retro adjustment • PDLD slope are decreasing as more losses are capped by maximum limits and per occurrence limits as time passes. Fitzgibbon does not take this effect in consideration so slope is constant
EXAMINER'S REPORT
Candidates were expected to have general knowledge of premium development, and the methods discussed in Teng/Perkins/Feldblum to address this development. Specific methods were listed with illustrations to make it clear precisely which method was to be discussed. In general, candidates struggled on less commonly used methods.
Part a
Candidates were expected to demonstrate they knew an advantage and disadvantage of the chain latter method which were specific to premium development. Common errors include: • Listing general advantages/disadvantages of the chain ladder method that were not specifically tied to the issues involved in retrospective policies (change in retro parameters). • Stating that this method used losses. • Stating that the method used data/experience, but not stating what data/experience was used. • For disadvantages, stating that not using losses was a disadvantage without linking to the lag between premium and losses.
Part b
Candidates were expected to demonstrate they knew a disadvantage of the Fitzgibbon method. Common errors include: • Stating that a disadvantage of the method was that it relied on developing ultimate

losses.

- Stating that the method did not react to a deviation from expected losses, which is not true. The method reacts to loss deviations through the ultimate loss selection. It does not react to a deviation from expected premium, or the ratio between premium and losses.
- Listing an advantage instead of a disadvantage.

Part c

Candidates were expected to demonstrate they knew any reason that directly caused the slope of Fitzgibbon to not be equal to 1.

Common errors include:

- Not understanding the meaning of unity.
- Restating the question without further explanation.

Part d

Candidates were expected to demonstrate they knew an advantage and disadvantage of the formula-based PDLD method with the Feldblum adjustment.

Common errors include:

- Responding with specific advantages of the PDLDM without Feldblum's adjustment.
- Giving an advantage/disadvantage related to the empirical PDLDM.
- Only stating that "it is more accurate" or "it is more difficult".

Part e

Candidates were expected to demonstrate they understood why the PDLDM would have different slopes than Fitzgibbon, and to identify a cause. Several of each are listed in both the Teng & Perkins reading and the Feldblum reading.

Common errors include:

- Stating that the different slopes were caused by Fitzgibbon fitting a regression on Ultimate loss, while the PDLDM fit on incurred loss.

QUESTION 19

TOTAL POINT VALUE: 3.75 | **LEARNING OBJECTIVE(S): B2**

SAMPLE ANSWERS

Part a: 0.25 point

Sample 1

k = 0.023 + 1.1(0.05) = 0.078

Sample 2

$k = r_f + \beta(E(r_m) - r_f) = 0.023 + 1.1(0.05) = 0.078$

Part b: 1.75 points

Sample 1

	2017	2018	2019	
Div	20,000(0.75) = 15,000	16,875	18,750	
Beg equity	100,000	105,000	110,625	
ROE = Net income/Beg equity	0.2	0.214	0.226	direct average = 0.213

g = ρ × ROE = 0.25(0.213) = 0.053

⇨ $V_0 = 15{,}000/1.078 + 16{,}875/1.078^2 + 18{,}750/1.078^3 + 18{,}750(1.053)/((0.078-0.053)1.078^3)$
= 673,828

Sample 2

Assume NI is after tax.

	2017	2018	2019
NI	20,000	22,500	25,000
Beg Eq	100,000	105,000	110,625
End Cap	105,000	110,625	116,875
Div Paid	15,000	16,875	18,750
ROE	0.200	0.214	0.226

Div Paid = NI × 75%   End Cap = Beg Eq + NI – Div Paid

Beg Eq = Prior End Cap   ROE = NI/Beg Eq

Since ROE is trending up, select last yr = 0.226

g = ρ ROE = (1-0.75)(0.226) = 0.0565

$$V_0 = \frac{15{,}000}{1.078} + \frac{16{,}875}{1.078^2} + \frac{18{,}750}{1.078^3} + \frac{18{,}750(1.0565)/(0.078-0.0565)}{1.078^3} = 778{,}892\text{k}$$

Sample 3

	2017	2018	2019
DTV ($M)	20×0.75 = 15	16.875	18.75
g = ΔCapital / Beg. Equity	20×0.25/100 = 5%	5.625 / 105 = 0.0536	0.0565
BE.	100	105	110.625
End. Equity	100 + 20×0.25 = 105	105 + 5.625 = 110.625	116.875

Since g is about the same, take a avg $\bar{g}$ = 5.34%

$V_0 = \frac{15}{1.078} + \frac{16.875}{1.078^2} + \frac{18.75}{1.078^3} + \frac{18.75 \times 1.0534/(0.078-0.0534)}{1.078^3}$ = 43.403 + 640.919 = 684.322

Part c: 1.25 points

Sample 1

	2017	2018	2019
Net Income	20,000	22,500	25,000
Begin Equity (from b.)	100,000	105,000	110,625
AE	12,200	14,310	16,371 = 25,000-0.078*110,625

PV(AE)=12,200/(1.078) + 14,310/(1.078)^2 + 16,371/(1.078)^3 = 36,700
PV(TV)=16371/(0.078)/(1.078)^3 = 167,542
V_0 = 100,000 + 36,700 + 167,542 = 304,242

Sample 2

Begin Equity 2017 100,000
Begin Equity 2018 100,000 + 0.25*20,000 = 105,000
Begin Equity 2019 105,000 + 0.25*22,500 = 110,625

Abnormal Earnings 2017 = 20,000 – 0.078 * 100,000 = 12,200
Abnormal Earnings 2018 = 22,500 – 0.078 * 105,000 = 14,310
Abnormal Earnings 2019 = 25,000 – 0.078 * 110,625 = 16,371.25

AE = 12,200/(1.078) + 14,310/(1.078)^2 + 16,371/(1.078)^3 +16371/(0.078)/(1.078)^3
= 204,244.6
Value of Insurer = 100,000 + 204,244.6 = 304,244.6

Part d: 0.5 point

Sample 1

Difference is mainly driven by the estimate of the terminal value of dividend (DDM vs AE). Terminal Value DDM is growing at 5.6% after projected period. (Realistically, high growth and high dividend are not sustainable at same time.) Terminal Value AE assumes constant abnormal earning after projection period. (More realistic if firm keeps up with its current operations.)

Sample 2

Abnormal Earnings focuses on value creation and short term forecasts of competitive advantage (this example assumes advantage continues in perpetuity) while DDM just discounts the consequences of value – the dividend. But above the DDM assumes a very high growth rate explaining the higher valuation.

EXAMINER'S REPORT

Candidates were expected to calculate the value of an insurer using the Dividend Discount Model and Abnormal Earnings approaches, and to explain the difference in the results that these two approaches produced.

Part a

Candidates were expected to calculate the insurer's risk-adjusted discount rate using the CAPM.

Candidates generally performed well on this portion of the question.

Part b

Candidates were expected to calculate the value of the insurer using the Dividend Discount Model. In order to perform the calculation, they needed to consider the information in the question in order to determine an appropriate growth rate to use in the calculation of the Terminal Value.

Common errors include:

- Without sufficient justification, only calculating the ROE/Growth for one year to estimate future Growth, without making the calculations for the other years in the forecast horizon.
- Calculating the Beginning Equities incorrectly, for example by adding the entire Net Income each year.
- Relying on the growth in the actual Dividends during the forecast horizon to estimate the future Growth – this leads to an infinite Terminal Value which is not reasonable.
- Assuming no dividends after the forecast horizon.

Part c

Candidates were expected to calculate the value of the insurer using Abnormal Earnings. Successful Candidates derived Abnormal Earnings and the Terminal Value assuming constant future Abnormal Earnings from 2019 forward then calculated the Value of the Insurer.

Common errors include:

- Making alternative assumptions without sufficient justification about the equity requirements for this part, and did not earn full credit for these assumptions unless a strong justification was provided. Examples of assumptions that did not earn full credit include:
    - Assuming all normal earnings are reinvested without justification.
    - Assuming all abnormal earning are reinvested without justification.
    - Assuming all net income is reinvested without justification.
- Assuming the growth rate from part b. in the Terminal Value calculation. This assumption is inconsistent with the statement of the question.
- Assuming that the abnormal earnings declined to zero beyond the forecast horizon. This assumption is inconsistent with the statement of the question.
- Forgetting to add the Book Value of the Insurer into the final Value of the Insurer.

Part d

Candidates were expected to explain the difference in the calculated value of the Insurer based on the two methods in part b. and part c.

Common errors include:

- Stating the definitions of the above methods without explaining the difference in the calculated values. For instance, "The dividend discount model values an insurer based on the present value of future dividends. The abnormal earnings method values the insurer based on the PV of future net income above the required return on capital + the beginning book value."
- Failing to explain difference between the results of the two methods in any meaningful way. For instance, "AE focuses on the value created while the DDM focuses on future cash flows to shareholders. Therefore the results in parts b and c are different."

QUESTION 20	
TOTAL POINT VALUE: 1.25	LEARNING OBJECTIVE(S): B1, B2
SAMPLE ANSWERS	

Part a: 0.75 point

Sample 1

FCFE = net income
+ non-cash charge
- net working capital
- change in required capital
+ net borrowing

Use the maximum of the two min-capital requirements, 115.

FCFE = 20,000 + 2,000 - (115,000 - 100,000) + 10,000

FCFE = 17,000

Sample 2

20 + 2 - 15 + 10 = 17

Part b: 0.50 point

Sample 1

1. Free cash flow to firm indirectly calculates the value by calculating total cash flow to the firm and subtracting debt. The difference between debt and policyholders liability is arbitrary.
2. Free cash flow to firm also requires calculating the weighted average cost of capital; this is complicated by the same issue as 1 -> the split between debt and PH liability is arbitrary but needed when calculating the WACC.

Sample 2

1. FCFF calculates the equity value by considering FCF to the firm -> firm value and then subtract the market value of the debt to get equity value. Since insurance companies have policyholder liabilities it's hard to distinguish that from debt issued, we have trouble figuring out how to treat PHL when subtracting debt value.
2. FCFF requires either the weighted average cost of capital (reflects risk to both debtholders and equity holders) or the all equity discount rate to discount the CFs. Again, due to the difficulty in distinguishing debt vs PHL, it's hard to come up with / calculate an appropriate discount rate for FCFF.

Sample 3

Due to policyholder liabilities, hard to calculate debt as needed for FCFF, or to calculate weighted average cost of capital for discounting.

Sample 4

Free cash flow to firm (FCFF) uses the weighted average cost of capital (WACC) since cash flows come from both equity and debt capital. Since it's hard to differentiate policyholder liabilities from other sources of debt, it's hard to precisely define WACC. Free cash flow to equity doesn't rely on WACC so it's not an issue.

FCFF also relies on adjusted present value (APV) which is also hard to define because it's hard to differentiate policyholder liabilities from other debt. FCFE doesn't need this.

Sample 5

Free cash flow to firm (FCFF) takes the total value of the firm then subtracts off debt. It is hard to distinguish policyholder liability from other debt.

FCFF uses a weighted average cost of capital which requires the average duration of the debt, which is hard to calculate for policyholder liabilities.

EXAMINER'S REPORT

Candidates were expected to understand the Free Cash Flow to Equity method for valuing the equity of a P&C insurer.

Part a

Candidates were expected to correctly identify and use the financial information provided to determine the Free Cash Flow to Equity as of year-end.

Common errors include:

- Incorrectly treating of amortized office furnishings expense, either by:
  - Excluding it completely
  - Correctly identifying it as a non-cash charge, but then incorrectly subtracting it instead of adding it
  - Incorrectly identifying it as a working capital expense/investment, thus subtracting it.
- Including the advertising expenses (cash charge) in any way.
- Failing to use the more binding (larger) capital constraint when determining the change in required capital.
- Dividing by anything to get a quotient as a final answer.

Part b

Candidates were expected to explain that the arbitrary distinction between traditional debt and a P&C insurer's policyholder liabilities (PHL) complicates the free cash flow to the firm (FCFF) method in two ways: (1) the discount rate used to value the firm in total and (2) the subtraction of the market value of debt.

Common errors include:

- Simply defining the FCFF and/or FCFE methods.
- Stating that the FCFE method is an easier/more direct calculation, without further explanation of what makes the FCFF method more challenging for a P&C insurer.
- Stating that the FCFE method is somehow a better representation of shareholder value, or more aligned with shareholders perspectives.
- Stating that the weighted average cost of capital (WACC) is "hard/harder/impossible to calculate" (or similar) without explaining why. Need to mention the arbitrary distinction between debt/PHL.
- Stating that the WACC is harder to calculate because it is a combined discount rate for equity and debt, without explaining why the addition of debt makes the calculation more challenging. Again, need to mention the PHL for a P&C insurer.
- Simply stating that the FCFF method "does not include policyholder liabilities" (or similar) without explaining that the FCFF method values the entire firm then subtracts the market value of debt, or without mentioning either the arbitrary distinction between PHL and

debt, or a lack of economic rational to treat PHL differently from debt.

- Simply stating that the policyholder liabilities are "hard to value", (or similar) without explaining that the FCFF method values the entire firm then subtracts the market value of debt, or without mentioning either the arbitrary distinction between PHL and debt, or a lack of economic rational to treat PHL differently from debt.
- Stating that either method uses measurements that management is more familiar with, or are more readily available from financial statements.
- Confusing policyholders liabilities with policyholders surplus or equity.

QUESTION 21

TOTAL POINT VALUE: 2 | **LEARNING OBJECTIVE(S): C1, C2**

SAMPLE ANSWERS

Part a: 1 point

Sample 1

- Transfer
- Avoidance
- Mitigation
- Acceptance

Sample 2

- Mitigation
- Transference
- Diversification
- Avoidance

Part b: 1 point

Sample 1

- Buy Reinsurance
- Exit the Market
- Increase deductibles
- Retain the exposure

Sample 2

- Only write policies on houses up to a certain limit (eg. Refuse homes over $500k to reduce severity
- Purchase reinsurance, issue CAT bond
- Offset hurricane risk on east coast with wildfire risk on the west coast. This should help overall company risk management
- Depending on country / state regulation, could issue policies that do not cover hurricane (much like flood in the US)

EXAMINER'S REPORT

Candidates were expected to know the four forms of traditional risk management, as well as strategies that an insurer could implement to manage its risk for each strategy listed in part a.

Part a

Candidates were expected to list four forms of traditional risk management.

Common errors include:

- Listing fewer than four forms of traditional risk management.
- Listing one type of traditional risk management multiple times with different words (for example, listing elimination and transfer as two separate responses, with the same meaning as implied by the part b. response)
- Listing types of risk instead of forms of risk management

Part b

Candidates were expected to briefly describe strategies than an insurer could implement to manage its risk for each strategy listed in part a.

Common errors include:

- Not listing a strategy for each type of risk management noted in part a.
- Providing a strategy that did not correspond to the form of traditional risk management that was listed (for example, purchasing reinsurance as a way to mitigate the severity of the risk when purchasing reinsurance is a form of risk transfer / elimination)
- Providing strategies to manage a different form of catastrophe (i.e. earthquake) than the hurricane in the question

QUESTION 22	
TOTAL POINT VALUE: 2.5	LEARNING OBJECTIVE(S): A1, A6

SAMPLE ANSWERS

Part a: 0.25 point

Sample 1
Parameter risk is the random uncertainty in the frequency and severity distributions of each line of business since the parameters and forms of these distributions are only estimates. This is a significant risk for insurance of all sizes because it is not able to be diversified.

Sample 2
Parameter risk reflects the imperfection of the model itself. The sources of uncertainty in ERM come from process risk and parameter risk. Parameter risk, unlike process risk, can't be diversified away. This makes parameter risk a key source of uncertainty.

Sample 3
Parameter risk is a key source of uncertainty because if an estimated parameter does not accurately reflect the true underlying parameter, then the projected results could be highly underestimated or highly overestimated.

Part b: 1.5 points

Sample 1
Renters: can introduce estimation risk. Estimating the form and parameters of a loss distribution requires data. This insurer doesn't have as this is a new line of business.

Homeowners: can introduce projection risk. Homeowner is an even more difficult case. In addition to the Estimation risk cited with Renters, Homeowners is subject to even more uncertainty over time due to changes in macroeconomic conditions and extreme weather events.

Livery: can introduce event risk, as it applies to ridesharing drivers, is still in its regulatory, legislative, and judicial infancy. A major court decision or legislative act could change the intent of policy coverage.

Sample 2
Renters: can introduce model risk. AS this is a new line of business the insurer may not be able to identify the appropriate model underlying the risk.

Homeowners: can introduce systemic risk. Systemic risk operates on large number of individual policies. They are, therefore, non-diversifying. As homeowners value is highly impacted by inflation, systemic risk will be an issue for the insuer.

Livery: can introduce estimation risk. Risk that since the insurer is expanding into this line of business, their data is limited and prone to bias and error. This will lead to estimated parameters being incorrect and biased if estimated from this data.

Part c: 0.5 point

Large insurance companies lower risk through diversification/volume. Parameter risk exists for each business segment and cannot be reduced by diversification/volume. With other risks mitigated through diversification/volume parameter risk make up a relatively larger risk for the large company.

Part d: 0.25 point

Sample Responses include any of the following:

- Having more data and better data quality
- More advanced regression procedures
- Testing sensitivity of results to the model (use multiple models to test)
- Combine /Weight together different Models
- Use Expert Judgment
- Test validity of results against available data.
- Use Compound simulation where parameters are selected from one distribution to be
- modeled in another
- Reduce any over-parameterization

EXAMINER'S REPORT

Candidates were expected to understand why parameter risk is an important piece of the total risk, which includes process risk and parameter risk. They were also expected to be able to identify and describe aspects of parameter risk.

Part a

Candidates were expected to show that they understood what parameter risk is and be able to relate it to **why** it is a key source of uncertainty (i.e. not merely provide a definition of parameter risk).

Common errors include:

- Describing parameter risk with no link to uncertainty of models.
- Saying that it is hard to estimate parameters.
- Just stating the aspects of parameter risk or defining parameter risk.

Part b

Candidates were expected to be able to identify three different aspects of parameter risk and be able to describe them in the context of entering into three new lines of business.

The following aspects of parameter risks were accepted:

a. Estimation risk
b. Projection risk
c. Event risk
d. Systematic risk
e. Model risk

Common errors include:

- Using catastrophes as part of an event risk since a catastrophic occurrence does not necessarily mean your estimated parameters were wrong.
- Some candidates identified data error and specification error as aspects of parameter risk

Part c

Candidates were expected to understand why parameter risk for large insurers is more significant than in smaller insurers.

Common errors include:

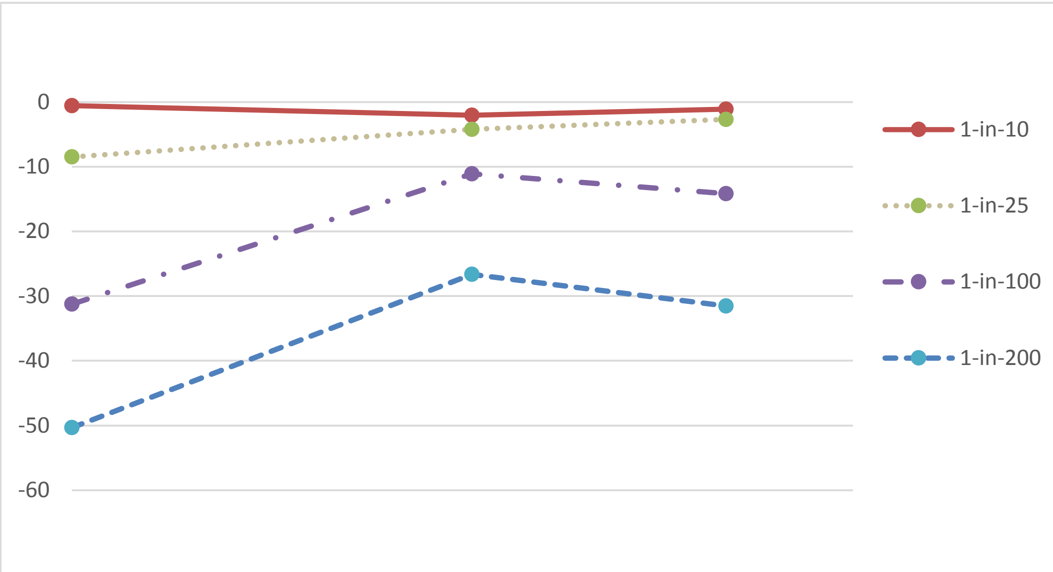
- Stating that large insurers deal with more lines of business and therefore have more parameters to estimate.
- Stating that large insurers have more correlations amongst the business they write.

Part d

Candidates were expected to be able to identify at least one way to reduce parameter risk. Candidates generally did well on this portion of the question.

QUESTION 23	
TOTAL POINT VALUE: 2.75	LEARNING OBJECTIVE(S): C2 and C6
SAMPLE ANSWERS	
Part a: 1.75 points	

Sample 1



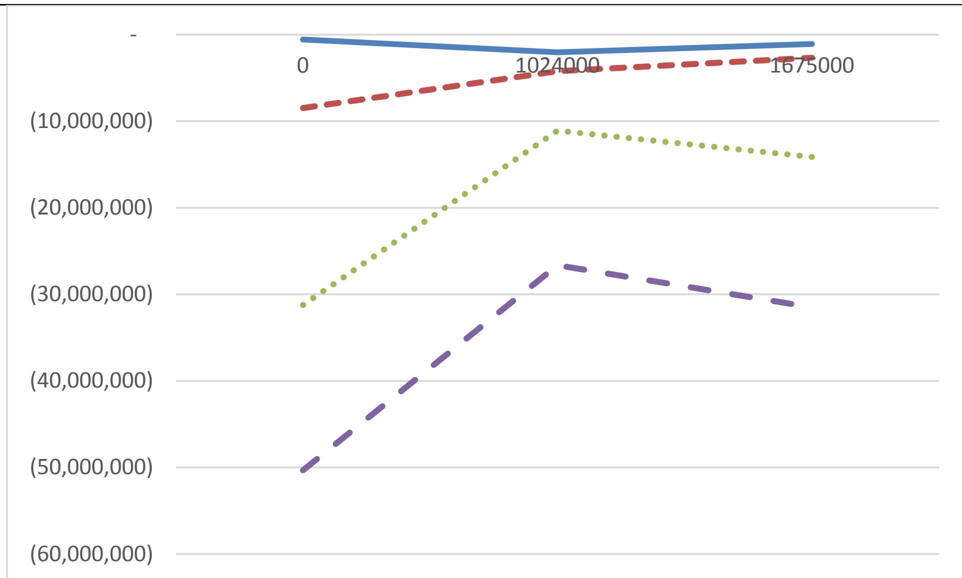
Vertical axis was labeled "Net Prem – Net Loss (M)"
Horizontal axis was labeled "(000) Prem – Recov"
At the bottom of the graph, the three positions below the sets of dots were labeled:

- 0 (bare)
- 1024 (alt)
- 1675 (curr)

Sample 2

Net cost
Bare = 0
Current = 4307-2632 = 1675
Alt = 2700 – 1676 = 1024

1 in 10 -> 10% prob level
1 in 25 -> 4% prob level
1 in 100 -> 1% prob level
1 in 200 -> .5% prob level



X axis was labeled "cost"
Y axis was labeled "Prem-Loss (benefit)"

Sample 3

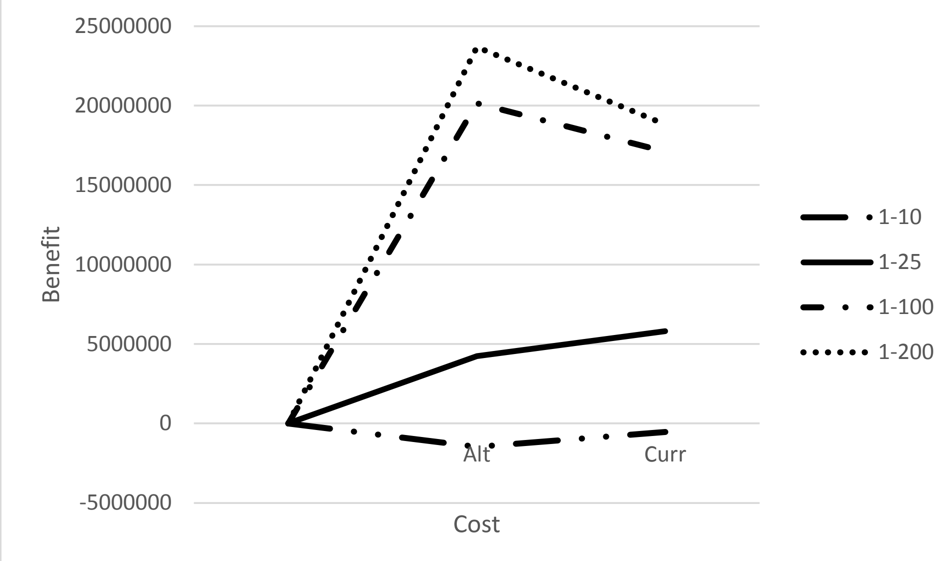
Benefit is decrease in losses compared to no reinsurance, cost is premium – recoveries

Prob	Benefit-Curr	Benefit-Alt
1%	-14,127,673- -31,211,388 = 17,113,715	20,147,193
4%	5,803,641	4,246,190
10%	-525,052	-1,469,122
.5%	18,809,445	23,683,774

Cost for Bare = 0

Cost Curr = 4,307,000 – 2,632,000 = 1,675,000

Alt = 1,024,000



Part b: 0.75 point

Sample 1

Recommend the alternative strategy since we have lower expected risk at a lower cost, especially evident at the 1-in-100 & 1-in-200 returns.

Sample 2

Alternative has worse results at 1 in 10 and 1 in 25 levels, but better results at 1 in 100 and 1 in 200 levels.

I recommend the alternative program as it provides more protection for extreme events and has a lower net cost. Would not choose bare because it provides no protection from extreme events.

Part c: 0.25 point

Sample 1

We could use the Gumbel or Heavy Right tail copula to better fit the right tail correlation seen in this model. These 2 copulas have more heavily correlated tails.

Sample 2

The Frank copula has little correlation in the right tail (0 when Z=1). For accumulation and clash events, we want correlation in right tail; use Gumbel copula instead to correlate.

Sample 3

Could use a copula that has greater correlation in the right tail, as these 2 LOB are likely highly correlated in the tail. Use the heavy right tail copula instead since it has greater correlation in the right tail.

EXAMINER'S REPORT

Candidates were expected to demonstrate an understanding of cost-benefit analysis as it applies to evaluating competing reinsurance programs, and were expected to know properties of various copulas and how appropriate those properties are for modeling reinsurance losses.

Part a

Candidates were expected to:

- Derive the cost of the Alternate and Current reinsurance programs.
- For each of the four percentiles, chart expected benefit against cost for all three reinsurance programs.

Common errors include:

- Displaying the four cost-benefit charts on separate graphs, without maintaining a consistent scale that would allow comparisons of the relative benefits of the three programs.
- Charting expected benefit against distribution percentile, instead of against cost.
- Not including the Bare program in their diagram. Some candidates performed the relevant subtractions to find the cost and benefit of the Alternate and Current programs relative to Bare, but to earn full credit, the candidate had to then identify the origin on their diagram as the Bare program.
- Not understanding that the net-premium-minus-net-losses distribution represented the (relative) benefit, while ceded premium minus expected recoveries was the cost.

Part b

Candidates were expected to identify the Alternate reinsurance program as the best of the three options, and mention both the lower cost and the higher protection in the tail of the distribution as supporting reasons.

Common errors:

- Selecting the Current program because the far tail was too unlikely or too difficult to model.
- Misunderstanding that the reinsurance structure cannot be selected after a given scenario has come to pass.

Part c

Candidates were expected to describe at least one way their proposed model improvement addressed a weakness in the model presented. This generally entailed providing support for the choice of a copula that provided more tail correlation than the Frank copula.

QUESTION 24	
TOTAL POINT VALUE: 2.75	**LEARNING OBJECTIVE(S): C7**
SAMPLE ANSWERS	
Part a: 1 point	
<u>*Sample Responses include:*</u> • If conditions worsen, underwriters will do whatever it takes to "make plan" (i.e., sell at inadequate price), leading to poor underwriting performance in the long run. • When actual conditions deviate from expected, management is reluctant to change estimates, thus booked loss numbers become more out of line with reality. • Loss ratios can be selected to be too optimistic, which can later result in higher losses than expected to due reserve development if we use a B-F approach to project the reserve. • A suboptimal portfolio mix may result. If management had known that the true loss ratio would be worse than the plan for a segment, they would have lowered the target premium volume for that segment. • If the company enters a different part of the insurance/underwriting cycle, the plan numbers could cause management to not act appropriately. For example, entering soft cycle and management encouraging growth to meet premium volume plan could be detrimental to quality of book. • The expected prior loss ratio in the plan may be based on prior years. If those prior years develop adversely, our plan may be too difficult to achieve (i.e., the plan was based on prior years which were too optimistic). • Plan loss ratios can highly correlated to prior years that may be inadequately reserved when budgeting is performed due to the bridging process.	
Part b: 0.75 point	
<u>*Sample Responses include:*</u> • Scenarios of the future state of the insurance market can be presented to management. Based on these scenarios, management can identify actions and goals they would like to achieve given the scenario. The plan can be set at the beginning of the year to align with the scenario that matches the current state. Then periodically, the state of the market will be evaluated and the goals and actions identified in the closely matched scenario will become the new plan. • Scenarios could be created for different marketplace conditions and best "plans" or goals could be thought out beforehand. This could allow "the plan" to change as the marketplace changes and save time when/if things change during the year so the company can be quick to respond. Set different expected loss ratios and WP targets by line for each scenario in order to maximize firm value. • Company could develop different scenarios (e.g., high, low, mid profitability). Then create responses to each scenario (e.g., grow, shrink, maintain WP). Then monitor situation and act according to which scenario emerged during the year. • The company could lay out a number of likely scenarios and develop plans for each. Then, if conditions change during the year, the company can shift to one of its alternate plans. For example, if the market turns soft during the year, the company can shift to a plan where premium volume decreases. • Under scenario planning, several scenarios will be defined and a likelihood or probability	

will be assigned to each. The company prescreens these and come up with agreed responses for each scenario, in sufficient detail to be implemented. The company then monitors the environment to determine which action plan needs to be implemented.
Part c: 1 point
Sample Responses include: • Since responses to different outcomes have been discussed ahead of time, management can quickly implement actions in event of a crisis. • Due to the added flexibility of additional plans, organizational inertia is avoided and managers feel more comfortable reporting numbers that deviate from the original plan. • Scenario planning forces the company to think through different significant events/external conditions and how they can potentially impact parts of the company. • Management has already discussed how they want to react in different market scenarios, so these plans are ready if market conditions do change (not figuring out strategy on the fly). • Underwriters will be less likely to take on risky business if they know their job performance will not be evaluated on meeting a single out-of-date plan in a soft market. • Allows for flexibility of underwriting incentives and goals based on the current state of the insurance market which will help the insurer's long-term profitability. • Can help create flexibility for deviation in results and remove organizational inertial since decisions have been agreed and discussed already. • Decreases the pressure to "make plan" no matter what, since it proposes changes if the environment dictates it.
EXAMINER'S REPORT
Candidates were expected to know how to describe operational risk and demonstrate possible mitigation and quantification methodology within the context of scenario planning.
Part a
Candidates were expected to demonstrate knowledge of two potential disadvantages of traditional unilateral planning. Common errors include: • Restating the same response that had been provided in part c. of this question as an advantage of scenario planning, but just rephrasing that concept to express an opposite disadvantage of unilateral planning. • Presenting a single drawback of unilateral planning with different phrasing in two separate responses to this question part. • Mentioning technical modeling concepts such as variables correlations, correlations among LOBs, inability to assess risk levels, etc. that would not be potential drawbacks unique to traditional unilateral planning. • Simply stating that the traditional unilateral planning approach is a single point estimate that does not give multiple scenarios or outcomes to review. • Stating only that the unilateral plan could miss significant scenarios that could result in unexpected loss to the company.
Part b
Candidates were expected to demonstrate knowledge of the three key steps in applying scenario planning within an insurance environment.

Common errors included:

- Not providing the final step of scenario planning to be implemented in an insurance environment.
- Stating that the company should develop scenarios for loss ratios without any mention of developing company action plans for each scenario.
- Stating only that scenario planning can help management think through different possibilities in what could happen in the market including tort reform, inflation, a catastrophe, etc.

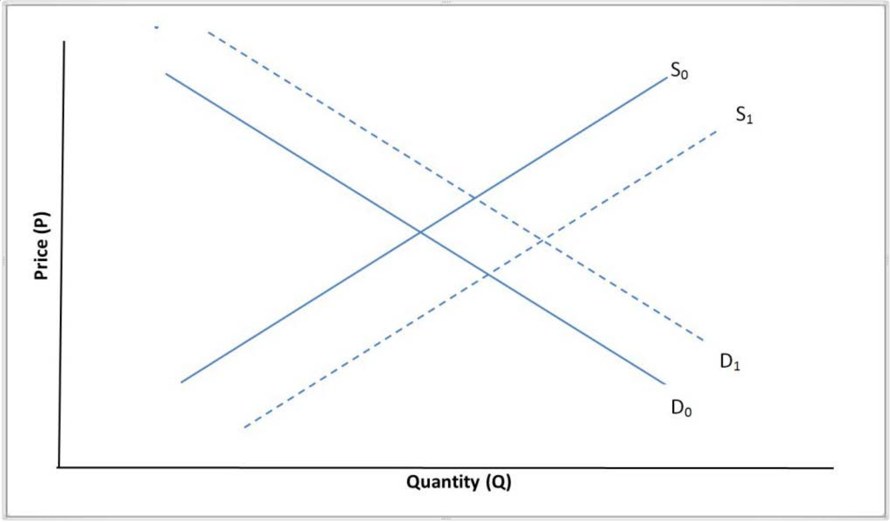
Part c

Candidates were expected to demonstrate knowledge of two potential advantages of scenario planning within an insurance environment.

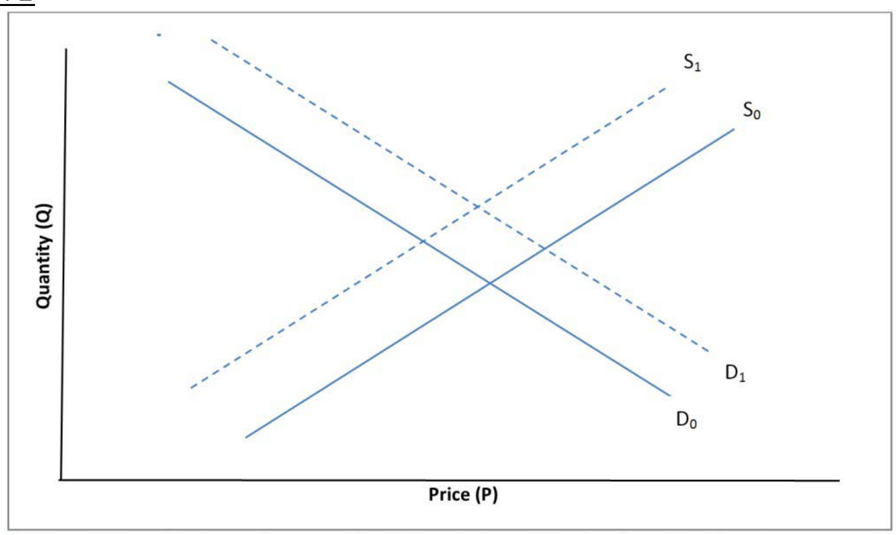
Common errors include:

- Restating the same response that had been provided in part a. of this question as a disadvantage of unilateral planning, but just rephrasing that concept to express an opposite advantage of scenario planning.
- Presenting a single advantage of scenario planning with different phrasing in two separate responses to this question part.
- Mentioning technical modeling concepts such as variables correlations, correlations among LOBs, inability to assess risk levels, etc. that could apply under any planning approach.
- Simply stating that scenario planning provides multiple points of view of the range of outcomes.

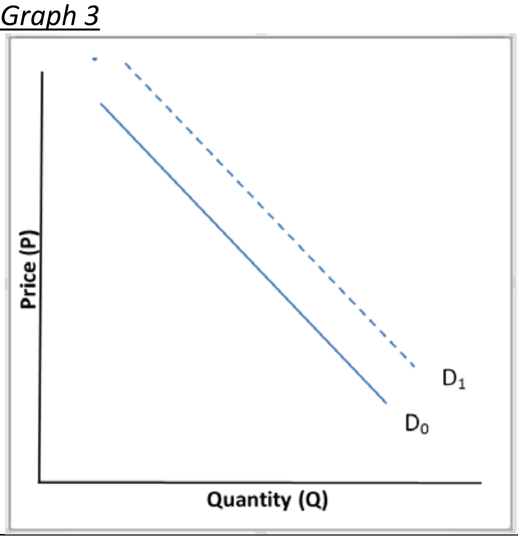
QUESTION 25	
TOTAL POINT VALUE: 1.75	**LEARNING OBJECTIVE(S): C8**
SAMPLE ANSWERS	
Part a: 0.5 point	
Sample 1 Behavioral approach – a middle ground between soft and technical approaches wherein several individual components of the process are built upon economic and behavioral theory. *Sample 2* Econometric modeling: uses a combination of soft and technical methods to understand behavior drivers of cycle and the impacts on supply and demand. *Sample 3* In between soft and technical approach. Model change in supply and demand in insurance, capital flows, etc. to model equilibrium price. *Sample 4* A behavioral approach combines elements from soft (human element) and technical approaches (mathematical rigor). It uses supply and demand to look at equilibrium prices. Adjust certain key inputs such as shock events, amount of capital, inflation, etc. which will influence the curves. Going through many iterations of the effect on the supply and demand curves creates a model of the underwriting cycle. *Sample 5* Econometric modeling is a behavioral approach to modeling the underwriting cycle. It incorporates mathematical formulas and rigor as well as the impact of human factors. By incorporating various components such as supply and demand curves, capital flows, etc. we are able to vary these assumptions to determine their impact on equilibrium prices and create an empirical distribution of potential future equilibrium prices, which can then be used to predict turns in the UW cycle.	
Part b: 1.25 points	
Sample Graph 1	

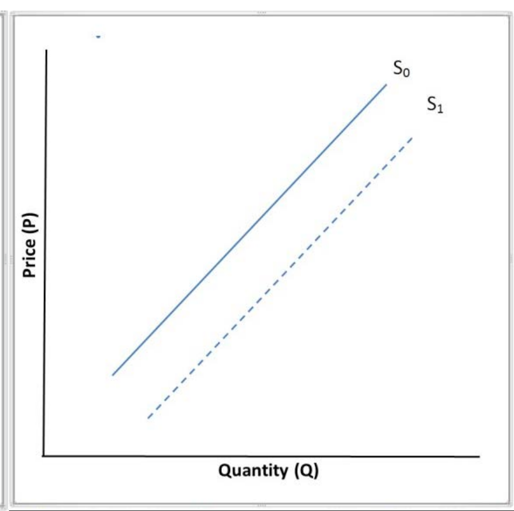


Sample Graph 2



Sample Graph 3





Sample Answers for the rationale behind the supply curve shift:

- Insurers will have increased capacity.
- Insurers will be able to take on more risk while remaining at the same probability of default.
- Insurers will be able to rely less on premium to provide them with capital and they can lower the price.
- Insurers will have more capital available to expand.
- Insurers will be willing to write more business.
- Insurers will be able to write more business.
- There will be more new entrants, increasing competition and driving prices down.
- More capital will lead to technical advancement; expense reduced.

Sample Answers for the rationale behind the demand curve shift:

- Insurance is worth more to the consumer because the insurer has a smaller probability of default.
- Consumers recognize the improved quality of the product.
- The insurers' promise is worth more because they have more money to pay claims.
- The insurers offer more protection.
- Consumers prefer well-capitalized insurers.
- Consumers prefer stable insurers.
- Consumers have more confidence in the insurance industry.
- A capital infusion increases an insurer's quality/capital quality.

EXAMINER'S REPORT

Candidates were expected to describe the behavioral approach to modeling the underwriting cycle and how it relates to the soft and technical approaches, as well as demonstrate understanding of the supply and demand component of the behavioral model by showing how and why the curves shift after a capital infusion.

Part a

Candidates were expected to demonstrate understanding of how behavioral approaches compare to soft and technical approaches, as well as give a high-level explanation of either how a behavioral model works or the motivation behind the behavioral model.

Common errors include:

- Providing insufficient explanations of the behavioral model.
- Describing soft approaches (Delphi method and competitor analysis) to modeling the underwriting cycle rather than behavioral approaches.

Part b

Candidates were expected to draw the supply curve shift and the demand curve shift on a correctly labeled graph (the equilibrium price could either be higher or lower, but the equilibrium quantity must be higher), and then describe the reasons behind each shift.

Common errors include:

- Drawing the supply and demand curves at the wrong angles, or drawing the shifts in the wrong directions. Some candidates struggled with the graph even when their verbal explanations were correct.

- Not showing any change to the demand curve.
- Not providing the rationale behind the shifts. Many candidates simply re-stated the direction of the shifts, without explaining why they occurred.
- Labeling the axes incorrectly.