

## 2010 Examinations

### SPECIMEN EXAMINATION

#### Subject ST8 — General Insurance: Pricing

#### Specialist Technical

*Time allowed: Three hours*

##### **INSTRUCTIONS TO THE CANDIDATE**

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all eight questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

##### **AT THE END OF THE EXAMINATION**

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

*In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.*

- 1**
- (i) Explain briefly the two types of variable which GLMs require in order to be defined. [3]
  - (ii) Define the term categorical factor in the context of GLMs, giving an example. [3]
  - (iii) Explain the expression “interaction term” in the context of GLMs. [2]
- [Total 8]

- 2** You are an actuary working for a newly established general insurance company. It commences writing household contents insurance on 1 September 2009 writing annual policies only. The company sells the following number of policies per month in 2009:

<i>Month</i>	<i>Policies sold</i>
September	1,000
October	1,500
November	2,000
December	2,500

- (i) Describe the claims characteristics of household contents insurance. [4]
  - (ii) Calculate the average accident date for accidents occurring during 2009 by considering the company’s exposure profile. Assume that policies incept on the first day of the month in which they are sold. State any other assumptions that you use. [4]
- [Total 8]

- 3** Explain the five key modules of a catastrophe model. [10]

- 4** Discuss the key reasons for monitoring general insurance business written. [10]

- 5** For a number of years a reinsurer has written a working layer per event risk XL treaty with unlimited reinstatements. The cedant places this treaty to protect the liability element of a large book of private motor vehicle insurance. The reinsurer has recently introduced a stability clause and an aggregate deductible to the layer.

- (i) Define each of these new features and explain the impact of their introduction on the expected cost of claims to the layer. [5]
  - (ii) State the advantages and disadvantages to both the reinsurer and the cedant of the addition of each of these new features to the layer. [6]
- [Total 11]

- 6** You are the actuary of a large general insurance company. You have been asked to price a “cross-class” deal for a customer. The policy will cover the customer’s motor fleet and public liability requirements. Another general insurance company has written the public liability cover in the past.

The proposed structure for the policy is as follows:

Motor: the general insurance company will provide unlimited cover for any individual loss.

Public liability: the limit of indemnity on any one individual loss is £250m.

The customer retains a deductible of £0.5m on each and every loss for the complete programme subject to an annual aggregate deductible of £15m.

- (i) Outline the concerns you would have with this proposed structure. [3]

The customer has provided you with a large database of their individual claims data, as well as relevant exposure measures, for the past 10 years.

- (ii) Explain how you would calculate a risk premium for this product using the information on this database. [10]

[Total 13]

- 7 A motor underwriter has approached you for assistance with a new business premium quote on a fleet of 100 heavy goods vehicles commencing 1 January 2010. She has supplied you with the following unprojected historical claims data from the existing insurer as at 31 October 2009.

Incurred Claim amounts in £000's

<i>Accident Year</i>	<i>Own Damage Incurred Costs</i>	<i>Third Party Damage Incurred Costs</i>	<i>Third Party Personal Injury Incurred Costs</i>	<i>Earned Vehicle Years</i>
2005	44	30	55	80
2006	56	32	61	88
2007	42	35	51	90
2008	70	50	35	92
2009	40	30	20	98

The following additional information is available:

The prospective insured has always renewed the policy on 1 January each year.

Damage inflation has been 4% p.a. for many years.

Personal Injury inflation has been 7% p.a. in each of the calendar years 2005 to 2007, then 9% p.a. from calendar year 2008.

Incurred Claims as a percentage of Annual Ultimate Projected Claims are estimated from internal data to be:

		<i>As at development month</i>			
	10	22	34	46	58
<i>Own Damage</i>	70%	95%	105%	102%	100%
<i>Third Party Damage</i>	45%	80%	95%	100%	100%
<i>Third Party Injury</i>	30%	55%	75%	85%	95%

Commission is 15%. Expenses are £100 per policy, £10 per vehicle and 7% of claims costs. Insurance Premium Tax can be ignored.

Profit and contingency loading is 5% of the overall gross written premium.

- (i) Estimate the annual premium to charge the prospective client, using the data provided, stating any assumptions you make. [11]

You have predicted that the average annual premium charged per vehicle during January 2010 on your company's existing account of 25,000 heavy goods vehicles will be £3,750. You decide to recalculate the premium using a credibility approach.

- (ii) Recalculate the annual premium assuming you use a credibility factor for the fleet's own experience as:

$$Z = \text{minimum } (1, 1 - \sigma/\mu)$$

where

$\sigma$  = the standard deviation of the yearly projected burning cost per vehicle observed from the five year data

$\mu$  = the average of the yearly projected burning cost per vehicle observed from the five year data [4]

- (iii) Explain why the premium charged in practice may not equal the premiums calculated in parts (i) or (ii). [5]

[Total 20]

**8** You are the actuary of a large general insurance company that only sells insurance to large international companies. The underwriters are considering entering the smaller end of the commercial market through the creation of a new product that covers the insurance needs of construction and engineering tradesmen who are either sole traders, partnerships or limited companies with up to five employees.

- (i) Describe the distribution channels through which this new product could be sold. [8]

- (ii) Compare the marketing methods in part (i) to those which would be used for the insurer's existing business. [2]

- (iii) Describe the types of commercial insurance that these tradesmen may wish to purchase. [10]

[Total 20]

**END OF PAPER**

**2010 Examinations**

**SPECIMEN SOLUTIONS**

**Subject ST8 — General Insurance: Pricing**

**Specialist Technical**

**1 (i) Weight / Exposure**

- These are the weights used in the model fit to attach an importance to each observation.
- For example in a claim frequency model exposure would be defined as the length of time the policy had been on risk.
- For an average claim size model, the exposure will be the number of claims for that observation.

**Response**

- This is the value that the model is trying to predict.
- Hence in the claim frequency model it is the number of claims for that observation for an average claim size model it is the total claims cost for that observation.

**(ii)**

- This is a factor to be used for modelling where the values of each level are distinct and often cannot be given any natural ordering or score.
- An example of this would be Car Manufacturer, which has various values “Ford”, “Vauxhall”, “Toyota”, “Lotus”.
- These could be ordered in a number of ways, alphabetically, sorted by exposure on risk, sorted by estimated risk.
- The ordering can help cosmetically when reviewing the results, but does not affect the calculations.

**(iii)**

- An interaction term is one where the pattern in the response variable is better modelled by including extra parameters for each combination of two or more factors.
- Each factor has a base level which should not be included in the model,
- for interactions each base level row and column of the interaction parameter matrix should be removed.

- 2 (i)**
- Claim event is usually sudden and easily determinable (e.g. burglary, fire)  
Notification is normally prompt  
Settlement is usually quick  
Often just consists of a single payment  
Claim amount can normally be estimated accurately  
Claims tend to be fairly consistent in size and distribution  
Frequency tends to be high relative to buildings cover  
As a class, very exposed to the risk of moral hazard  
Frequencies closely linked to the economic cycle,  
e.g. theft claims frequencies rise when unemployment rises

- (ii) Assume all policies earn uniformly over the year  
 Claim frequency per unit exposure remains constant over the year  
 Claims occur on average mid-month  
 (In each case, alternative assumptions are valid if correctly applied.)

(1)	(2)	(3)	(4)
<i>Month</i>	<i>Policies written</i>	<i>Earned exposure = policies on risk</i>	<i>(Month – 0.5) × earned exposure</i>
9	1,000	1,000	8,500
10	1,500	2,500	23,750
11	2,000	4,500	47,250
12	2,500	7,000	80,500
	7,000	15,000	160,000

Average accident date =  $\text{sum}(4)/\text{sum}(3) = 10.667$ , i.e. two-thirds of the way through November 2009

### 3 Event module

- A database of stochastic events (the event set) with each event defined by its physical parameters, location and annual probability/frequency of occurrence

#### Hazard module

- This module determines the hazard of each event at each location.
- The hazard is the consequence of the event that causes damage
- for example: in the case of a hurricane, wind speed is the primary cause; for an earthquake, it is ground shaking.
- Defines the potential damage vulnerability to a particular type of structure caused by a specific event.
- The hazard component can be “conditioned” with scenarios from climate model projections to represent, for example, the hazard in 2050 for coastal flood risk in the region of concern.
- Must incorporate at least three variables regarding the source parameters of the hazard, location of future events, frequency of occurrence and their severity.

#### Inventory (or exposure) module

- A detailed exposure database of the insured systems and structures.
- As well as location this will include further details such as age, occupancy, construction.
- Building inventory is important to estimate potential future losses to structures and assets of elements at risk.
- Also the special distribution should be captured.
- E.g. for earthquake damage estimation, engineered buildings in the inventory should also reflect regional differences in construction practice and building codes.



### **Vulnerability module**

- Vulnerability can be defined as the degree of loss to a particular system or structure resulting from exposure to a given hazard (often expressed as a percentage of sum insured).
- The vulnerability module, which translates hazard into building specific damage based on engineering science and claims data, can be tuned to represent specific adaptation measures.

### **Financial Analysis module**

- Uses a database of policy conditions (limits, excess, sub limits, coverage terms) to translate the total ground-up loss into an insured loss.
- Applies the damages against insurance and reinsurance contract specifications to determine the financial losses from an event.
- The financial module subsequently outputs estimates of annual loss, and return period (i.e. probabilistic) loss.
- The Inventory and Financial Analysis modules rely primarily on data input by the user (an insurer or reinsurer) of the models.
- The data will be specific to the user.
- The Event, Hazard and Vulnerability modules represent the engine of the catastrophe model.
- The Event and Hazard modules are based on seismological and meteorological assessment
- and the Vulnerability module is based on engineering assessment.

## **4**

- Assessing performance against the organisation's goals.
- The ultimate goal for most general insurance companies is to exceed a minimum level of profit or return on equity for a given level of risk.
- However, companies will break this objective down into more specific targets.
- The hope is that if these individual targets are met then so will the overall company objective.
- A general insurance company will monitor the business it has written in order to gauge its performance against these targets.
- This enables informed planning and decision making.
- Managing risk
- Monitoring written business allows the company to assess how much risk is inherent in the portfolio (e.g. accumulations).
- The amount of risk will be a factor in determining how much capital the company should hold and what its reinsurance purchasing strategy should be.
- Gaining market intelligence
- Monitoring written business can provide useful information about competitors' strategy.
- It can also allow the company to compare itself with the market and assess the underwriting cycle.
- Satisfying regulators
- Market regulators may require periodic monitoring and reporting of written business.

- Influencing the market
- A company may be able to influence the market by publishing the results of its monitoring exercises.
- Reserving
- The outputs of any monitoring exercise can be used for other purposes such as an input in to the reserving process.
- Considered in isolation this would not necessarily be a reason to monitor written business.
- The most common example is the use of rate indices (derived from the monitoring exercise) to adjust a-priori loss ratios (often called initial expected loss ratios) in Bornhuetter-Ferguson reserving methods.
- Part of the Actuarial Control Cycle
- Another reason for monitoring would be to validate assumptions in a model.

## 5 (i) **Aggregate Deductible**

Introduction of the aggregate deductible means that now the sum of the claims to the layer must exceed the deductible before the cedant can make a recovery so for a given amount of exposure, expect the aggregate deductible to reduce the cedant's expected recovery and increase the cedant's retention.

*The extent of the impact of the aggregate deductible depends on:*

the size of the aggregate deductible (for a given exposure in vehicle years)  
the expected number and severity of losses to the layer (for a given exposure in vehicle years)  
e.g. large aggregate deductible relative to expected number/size of losses  
means lower recoveries for the cedant (and vice versa for a small aggregate deductible)

### **Stability Clause**

Before the stability clause applied, the expected value of total losses to the layer would have increased annually (all else being equal) because of:  
the effect of TPBI inflation on severity of individual losses to the layer (i.e. the conditional expected value of a loss to the layer increases with inflation)  
and the gearing effect of TPBI inflation increasing the frequency of losses to the layer (i.e. probability of a loss to the layer increases with inflation).

A stability clause means the attachment point and layer limit are adjusted in line with some specified index (e.g. fixed x% p.a. or a healthcare cost index) so the layer widens with each application of the index  
e.g. £1m xs £1m indexed by 5% is £1.02m xs £1.02m

*Adding the stability clause has the following expected impact*

The frequency of losses to the layer drops over time e.g. a claim that starts in the layer may settle below the layer.

For a given loss, its actual attachment point depends on the settlement date (i.e. the attachment point will increase in line with the stability clause index until the loss settles).

The actual impact of the stability clause depends on the cedant's actual claims experience and on the inflation in TPBI claims relative to the index applied to the layer.

(ii) **Reinsurer**

- + stability clause ensures alignment of interest by encouraging faster claims settlement (as net retention increases with each year due to the indexation of the attachment point and limit),
- + stability clause gives some protection against expected future inflation in the claims to the layer
- + aggregate deductible reduces exposure to the cedant and allows the reinsurer to use capital elsewhere
- + benefits if the sum of claims to the layer doesn't breach the aggregate deductible or claims settle below the indexed attachment point

- actual claims inflation may outstrip the indexation thereby eroding the benefit of the stability clause over time (likely in practice)
- lower premium income with introduction of aggregate deductible
- more volatility in claims cost to the layer relative to the premium charged

**Cedant**

- + the aggregate deductible reduces reinsurance spend (especially beneficial if reinsurance rates are hard)
- + can use the aggregate deductible to manage risk appetite
- + the aggregate deductible means higher expected profit as ceding less to the reinsurer generally means ceding less profit
- + cedant can manage total exposure to the reinsurer (reinsurer security impacts capital requirement)

- aggregate deductible delays recoveries (cashflow implications)
- greater loss retention, so alternative source(s) of capital required (alternatives may be more costly).
- greater volatility in the retained losses
- retains some inflation risk i.e. if the TPBI inflation is lower than the indexation, then more likely that a claim estimated to settle in the layer settles below the layer

**6**

(i)

- Once the £15m aggregate is exhausted, cover reverts to general insurance company, so a single bad year could be very expensive
- Unlimited coverage for motor — potential for large single loss
- Large limit for public liability — potential for large single loss
- Do we have/need reinsurance coverage to protect against this

- Perhaps consider negotiating with customer on a structure with lower exposure
- Need to clarify if the excesses/limits cover e.g. legal expenses

(ii)

- Model the motor and public liability accounts separately, for each one
  - Need to model the frequency and severity separately in order to apply deductible
  - Use client's data as start point (since large dataset)
  - Pick a base period
  - Adjust the claims for inflation
  - Adjust for change in exposure
  - Adjust for trends in data
  - Adjust for any changes in terms and conditions over period considered
  - Compare outcome with any internal portfolio/external benchmark data
    - especially for large loss assumptions
    - Consider credibility weighting to portfolio/benchmark
- Consider any relationship between claims received under motor and public liability
  - Unlikely to be strong so probably model as independent.
- Could use deterministic modelling approach to determine parameter estimates for frequency and severity for each cover
- Determine the mean values for both parameters
- Alternatively could model the outcome of the individual accounts using stochastic modelling approach
- Carry out several thousand simulations and apply the product "rules" to the outcome
- The average outcome to the insurer in the simulations will give the expected loss cost to the insurer
- This would also provide the range of possible claims experience scenarios which could assist in determining suitable reinsurance arrangements

- 7** (i) Project the claims costs and inflate to 2010 levels to derive a burning cost

**Assumptions**

No further tail factor required after 58 months development for all claim types

Assume claims inflation in 2010 = claims inflation in 2009

Development factors are on the same basis as claims stats

Projected Claims Costs (before claim inflation allowance)

<i>Year</i>	<i>Damage Costs</i>	<i>Third Party Personal Injury Costs</i>
2005	74	58
2006	87	72
2007	77	68
2008	136	64
2009	124	67

Amounts in £000

Claim inflation adjustments to 2010

<i>Year</i>	<i>Damage Costs</i>	<i>Third Party Personal Injury Costs</i>
2005	$1.04^5 = 1.217$	$1.07^2 \times 1.09^3 = 1.483$
2006	$1.04^4 = 1.170$	$1.07 \times 1.09^3 = 1.386$
2007	$1.04^3 = 1.125$	$1.09^3 = 1.295$
2008	$1.04^2 = 1.082$	$1.09^2 = 1.188$
2009	1.04	1.09

Projected Claims Costs (after claim inflation allowance)

<i>Year</i>	<i>Damage Costs</i>	<i>Third Party Personal Injury Costs</i>
2005	90	86
2006	102	99
2007	86	88
2008	147	76
2009	129	73
Total	554	422

Amounts in £000

$$\begin{aligned} \text{Burning Cost per vehicle} &= (554 + 422) \times 1000 / (80 + 88 + 90 + 92 + 98) \\ &= \text{£}2,178 \end{aligned}$$

$$\begin{aligned}\text{Gross Premium to charge client} &= (\text{number of vehicles in 2009} \times \text{burning cost per vehicle} \times \text{claims costs} + \text{policy expenses} + \text{vehicle expenses}) / \\ &= (100 \times 2178 \times 1.07 + 100 + 10 \times 100) / (1 - 0.15 - 0.05) \\ &= \text{£}292,683\end{aligned}$$

Bonus mark for identifying and allowing for any legitimate trends in the data, e.g. improvement in PI peril

(ii) Yearly burning cost observations

$$\begin{aligned}2005: & 175,872/80 = 2,198 \\ 2006: & 201,106/88 = 2,285 \\ 2007: & 174,499/90 = 1,939 \\ 2008: & 222,903/92 = 2,423 \\ 2009: & 201,429/98 = 2,055\end{aligned}$$

$$\mu = (2198 + 2285 + 1939 + 2423 + 2055)/5 = 2,180$$

$$\begin{aligned}\sigma &= \text{Square root of } \{(5 \times (2198^2 + 2285^2 + \dots) - (2198 + 2285 + \dots)^2) / (5 \times 4)\} \\ &= 190\end{aligned}$$

$$\begin{aligned}\text{Therefore } Z &= \min(1, 1 - 190/2180) \\ &= \min(1, 1 - 0.087) \\ &= 0.913\end{aligned}$$

$$\begin{aligned}\text{Therefore revised gross premium} &= Z \times 292,683 + (1 - Z) \times (100 \times 3750) \\ &= \text{£}298,932\end{aligned}$$

Note: alternative approach: one could strip out the claims cost from the average premium and then blend claims costs and reconstruct gross premium from that.

- (iii) the 5 year historical claims experience may be heavier or lighter than is expected in 2010  
potential large losses in historical data distorting the calculations  
competitors may have different assumptions in calculating the premium, for example lower fixed expenses, reduced acceptance of profit or different projection/inflation assumptions so offering lower quotes  
own company may be willing to take a reduced profit or slight loss on this business as the policyholder has other insurance contracts with the company that are highly profitable.  
using the company's own heavy goods vehicles experience may be inappropriate, for example the account may have a different business mix to that of the client (e.g. age of drivers, location of vehicles).  
cover provided in 2010 differs from that in previous years (e.g. increased own damage excess)  
different policy wordings/restrictions expected to reduce claims costs/numbers

expected future external events (e.g. changes in legislation) that may impact claims costs, expenses, commission or profit allowances  
per policy expense allowance in main account may be disproportionately higher than that required under a fleet contract  
influence of broker/customer (e.g. volume of other business offered by broker/customer)  
position in the market cycle

## **8**

### **(i) Brokers**

- A company which acts as an intermediary between the seller and the buyer of the insurance product without being tied to either party.

#### **Banks, Building Societies and other financial institutions**

- A company whose main activities include providing financing to small businesses and can therefore cross-sell insurance on the back of loan arrangements.

#### **Trade Associations**

- A union whose main activity is to provide support and advice to companies of a similar trade who can provide insurance products tailor-made to their requirements.

#### **Internet**

- The insurance company can develop a web-based sales point with the customer entering all the relevant rating information through the internet to obtain a quote for insurance.

#### **Telesales**

- A call centre arrangement managed by the insurance company to provide in-calls and out-calls to potential clients.
- In-calls can be through advertising in press or telephone directories whilst out-calls can be through leads generated from commercial tradesmen databases.

#### **Direct mailshot**

- The insurance company can directly target potential clients through the posting of literature to small business tradesmen.  
Employed staff paid by salary or commission.
- Staff of the insurance company visit the potential clients face to face to discuss their insurance requirements based on their circumstances.

### **Trade Retailers and other affinity groups**

- A company whose main activities are non-insurance related (e.g. a building supplies wholesaler) but whose organisation has a significant Commercial customer database to target sales.

(ii)

- Companies of all sizes (small and large) may use Commercial brokers as they can offer advice on their specific insurance needs.
- Companies of all sizes could be a part of a trade association.
- The remaining distribution methods are more likely to be used mainly by small businesses due to:
  - the relative speed and ease of obtaining low cost insurance
  - the far greater propensity for clients to use the distributor for other non-insurance activities

(iii) **Public Liability**

- The insured is indemnified against legal liability for the death or bodily injury to a third party.
- Or for property damage belonging to a third party.
- Other than those liabilities covered by other liability insurance.

### **Employers Liability**

- The insured is indemnified against legal liability to compensate an employee or temporary employee for the death, disease or bodily injury suffered owing to the negligence of the employer during the course of employment.

### **Contract Works**

- Indemnifies insured against loss of or damage to contract works property being worked on and materials.

### **Plant insurance (Hired or Own Plant)**

- Indemnifies insured against loss or damage to plant whether it is hired or owned by the insured.

### **Employees Tools All Risks**

- Indemnifies insured against loss or damage to tools used in the course of trade.



**Personal Accident/Sickness**

- Indemnifies all people specified under the cover for loss of earnings in an event of an injury or accident, whether temporarily or permanently out of work.

**Professional Indemnity**

- Indemnifies insured against legal liability resulting from negligence in the provision of a service (e.g. inaccuracies in architectural building design)
- Vehicle insurance (vans, pickups, goods vehicles, trucks, lorries).
- Property Damage — indemnifies insured against loss or damage to their own vehicles.
- Third Party Liability — indemnifies insured against compensation payable to third parties for damage to their vehicle or property or for personal injury.

**END OF SOLUTIONS**

# EXAMINATION

29 April 2010 (pm)

## Subject ST8 — General Insurance: Pricing Specialist Technical

*Time allowed: Three hours*

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- 1** (i) List possible parameters within the event set of a hurricane catastrophe model. [1]
- (ii) List other natural perils for which a catastrophe model is commonly used. [1]  
[Total 2]
- 2** (i) Define “risk factor” and “rating factor”. [2]
- (ii) Explain, using examples, the difference between them. [3]  
[Total 5]
- 3** A general insurance company plans to create a system for monitoring lapse experience at renewal for a book of business.
- (i) Describe, giving examples, the key features of a good system for this purpose. [7]
- (ii) List the data that is likely to be required for the system. [2]
- The company plans to introduce a range of operational initiatives designed to reduce the proportion of customers who do not renew their policies after receiving a renewal invitation. It wishes to monitor the effect of the initiatives as quickly as possible to help decide whether to continue them.
- (iii) Explain the difficulties that the company is likely to have with measuring the change in lapse experience and how these might be overcome. [5]  
[Total 14]
- 4** (i) State what is meant by a soft insurance market. [1]
- (ii) Discuss the reasons why general insurance companies may wish to continue writing business during a soft market. [4]
- (iii) Describe and evaluate strategies that a London-market insurance company might adopt during a soft market. [7]  
[Total 12]

- 5** The following table shows pure loss cost Increased Limit Factors for a class of business.

<i>Limit</i>	<i>ILF</i>
100,000	1.00
200,000	1.47
500,000	2.05
1,000,000	2.68
1,500,000	3.03
2,000,000	3.18

- (i) Calculate the ILFs for the following two layers:

- (a) 1 million xs 0.5 million  
(b) 1 million xs 1 million

[1]

An underwriter has asked an actuary to analyse two different possible sets of contract terms for a proposed liability insurance contract:

Option A – 1 million xs 0.5 million for a premium of 20,000  
Option B – 1 million xs 1 million for a premium of 10,000

- (ii) Determine which option appears to be more profitable, using the ILF table provided. [2]
- (iii) Suggest further comments that the actuary might make to assist the underwriter. [3]

The actuary wishes to use the ILFs in the table to price a three-year contract starting on 1 January 2011 but discovers that the ILF curve was specifically built for calendar year 2009. Claims inflation has been 5% per annum on average in recent years.

- (iv) Stating any assumptions you make:
- (a) Calculate revised ILFs for limits of 100,000 and 200,000; and
- (b) Calculate the ILF of layer 100,000 xs 100,000 for this contract. [6]
- [Total 12]

- 6 In July 2010, an underwriter of a London-market general insurance company approaches the company actuary about pricing an insurance policy that is due for renewal in 2010. He asks the actuary to give him an early opinion on an appropriate price for the purposes of preparing the renewal. He expects to get more-detailed information closer to renewal. The policy concerns marine hull insurance. The following information is available.

- The insurance company has underwritten the policy since 1 October 2007.
- Over that period deductibles have not changed.
- Policies have always been annual and renewed on 1 October.
- The “policy year” runs from 1 October in the year indicated to the following 30 September.

The claims department provides the following claims data for the policy.

<i>Policy Year</i>	<i>Incurred Claims (\$)</i>	<i>Comments</i>
2007	3,317,000	
2008	8,600,000	Includes 1 large loss of \$5 million
2009	15,000	

From the insured company’s website the actuary finds the gross tonnage (GT) of the insured’s fleet at particular historical points, as follows.

<i>Date</i>	<i>GT (millions)</i>
01/01/2008	1,909
01/01/2009	1,970
01/01/2010	2,017
01/01/2011	2,050
(estimated)	

The actuary decides to use GT as the exposure measure.

- (i) Estimate the GT for each of the four policy years commencing 1 Oct 2007 to 1 Oct 2010 inclusive, stating any assumptions that you make. [4]

The actuary estimates that total “non-large” losses in each policy year are currently developed to the following proportions of their ultimate levels:

<i>Policy Year</i>	<i>Proportion</i>
2007	95%
2008	60%
2009	45%

The actuary also decides that any individual loss of over \$500,000 should be capped at \$500,000 and treated as “non-large” prior to estimating ultimate claims.

- (ii) Estimate the ultimate “non-large” claims for policy years 2007 to 2009. [2]

- (iii) State an alternative approach to calculating the ultimate claims for policy years 2008 and 2009. [1]
- (iv) Estimate the “non-large” losses for the 2010 policy year, ignoring claims inflation and stating any assumptions that you make. [3]
- (v) Estimate a large-loss loading for the 2010 policy year, ignoring claims inflation. [2]

Because of trends observed in the market as a whole the actuary decides that he should incorporate some claims inflation since 2007 into his calculations.

- (vi) Describe how this would alter the analysis in (iv) and (v), particularly regarding the treatment of the deductible. [3]
- [Total 15]

**7** Company B, a general-insurance broker, has for several years arranged general insurance. All policies have been underwritten by a single general insurance company, S. B is planning to set up a new arrangement under which it will broke policies to a panel of general insurance companies instead of solely to S. Each policy will be underwritten by the panel member offering the lowest quote net of commission. Panel members may decline to quote for each risk, but each policy will be reoffered to all panel members on renewal.

A general insurance company, U, has been invited to join the panel.

- (i) List the data that U should request from B for the purpose of creating a pricing structure. [4]
- (ii) Discuss the most likely sources of error or distortion in the data requested by U. [5]

U is disappointed with the quality of the data supplied by B, particularly for sole traders and for liability covers.

- (iii) Explain the likely effect of the inadequate data on U if it creates a pricing structure based on it. [3]
  - (iv) Suggest measures that U could take to mitigate the effects of using the poor-quality data. [4]
- [Total 16]

**8** The Claims Director of a general insurance company has received a report on claims frequencies for its household-contents business. The report shows that policyholders with a professionally-maintained burglar alarm linked to the police have a higher overall frequency of theft claims than policyholders with a lower standard of security. The Claims Director is aware that the Company offers lower prices for policyholders with higher standards of security so would like to understand the reason for the apparent contradiction. The company uses a generalised linear model to assess claims cost for the policies.

(i) Discuss the matters that should be investigated and points that should be raised in a reply to the Claims Director. [6]

(ii) Outline analyses of rating factors in the claims model that could help to illustrate the reply. [3]

[Total 9]

**9** Nine months ago a general insurance company underwrote a new motor fleet policy covering 1,000 vehicles. Based on its normal premium-rating assumptions the insurance company expected a claim frequency of 16% per year. To date, 109 claims have been received, and the promptness with which claims have been reported suggests that there are no claims that have been incurred but which have not been reported.

The contract is now being considered for renewal and the underwriter has asked whether or not it is appropriate to rate the new contract on the basis of its claims experience to date.

(a) Explain whether or not you think that this is likely to be appropriate; and

(b) Suggest a claims frequency that might be used in the re-rating.

Base your answers on credibility theory and state any assumptions that you make.

[7]

**10** A small well-capitalised London-market insurance company underwrites a variety of direct commercial and industrial property and liability insurance. Outline, with reasons, the types of reinsurance it is likely to buy. [8]

**END OF PAPER**

# **EXAMINERS' REPORT**

April 2010 examinations

## **Subject ST8 — General Insurance: Pricing Specialist Technical**

### **Introduction**

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

R D Muckart  
Chairman of the Board of Examiners

July 2010

### **Comments**

These are given in italics within the solutions that follow.



- 1** (i) Track/path, maximum wind speed, storm radius, forward speed, rate of decay of wind, probability/frequency  
Duration and time of year are not valid points.

*This question was reasonably well answered but definitions were sometimes technically weak; for example, the general term “location” might be given rather than the more specific “track/path”*

- (ii) Tornado, hail, earthquake, winter storm, Californian wildfire, flood/storm surge

Typhoons and cyclones are hurricanes and covered under (i). Disease and tsunami are not commonly modelled using cat models and are therefore not valid answers.

*This question was generally well answered, although some candidates seemed to be following a “scattergun approach”, listing all possible catastrophes and evidently hoping that correct ones would get marks. Some candidates listed non-natural perils in this approach. The examiners were looking for perils that are commonly treated with models.*

- 2** (i) Risk factor: a factor that is expected to have an influence on the intensity of risk in an insurance cover, possibly with the support of statistical evidence.

Rating factor: a factor that is used to determine the premium rate for a policy, that is measurable in an objective way and related to the intensity of the risk. It must, therefore, be a risk factor or a proxy for a risk factor or risk factors.

*This question was generally well answered, but only a few candidates mentioned statistical evidence*

- (ii) A risk factor might be predictive but impossible to measure/verify  
For example, driving skill, traffic density (or similar valid example)  
Or it might be susceptible to manipulation by the policyholder and therefore not objective.  
In this case rating factors are required as proxies.  
For example, policyholder age, occupation and postcode as proxies for driving skill/time on the road  
Claim-free years and NCD are also proxies and substitutes for experience rating.  
Rating factors should not be closely correlated to other rating factors  
They should be acceptable to the market  
And permissible by regulations/law

Some of the points in (ii) might well have been made as valid points in (i), and would have been given credit accordingly.

These examples are strongly linked to motor; answers that referred to other classes of business are perfectly valid.

*This question was reasonably well answered but on the whole answers should have been communicated more concisely.*

**3** (i)

- The system would typically include:
  - a data capture process;
  - calculations and/or manipulations on the data;
  - a process for reporting the results.
- Output should be concise and focused on the specific goals of the organisation.
- Examples:
  - The aim to reduce the lapse rate for profitable policies) or other valid example of focus)
- Output should be oriented to decision-making.
- And produce lapse rates by all important parameters
  - Such as rating factors
  - Regions
  - Distribution channels
- Examples:
  - Flag where lapse experience is outside of tolerance and action is required. [Or other valid example of decision-orientation]
- Data and results should be reliable and validated (as part of the actuarial control cycle).
- Examples:
  - Compare historic mix of business with later renewal experience. [Or other valid example of validation]
- Data should be complete
- Calculations should be well-defined but not over-complex.
- Examples:
  - Lapse volume should have a clear definition of how it treats policies not taken up, cancelled mid-term or “churned” to another policy type. [Or other valid example of calculation clarity]
- Data should be easy to collect.
- System should be documented,
- extendable
- and low-maintenance.
- System and output should be clear and easy to use
- Inputs and outputs should be consistent over time and with other analyses.
- Examples
  - If definition of lapse rate changes then it should be restated for all time periods.
  - Lapse rates reported at the same level of granularity as other business metrics. [Or other valid example of consistency]
- Results should be available as soon as possible after experience has occurred.
- Clear ownership and responsibilities for various part of the system e.g. data entry, changing output.
- Staff need to be kept trained and competent
- Limited access to the system e.g. only certain people can enter new data
- Linked to and/or compatible with other systems.

- Input should be consistent with other data sources.

***Most candidates did not give a sufficiently detailed answer, some selecting a small number of points and discussing them in detail. Some candidates gave formulae for calculating lapse rates, which was not an answer to the question and gained no credit.***

(ii) *Policy-by-policy data*

- Cover type at date of lapse
- Commencement date or duration in force.
- Effective renewal date.
- Actual renewal date if renewed.
- Cancellation date if cancelled.
- Key rating factor and policy details at time of renewal (if segmented analysis)
- Premium immediately before renewal.
- Renewal premium offered.
- Actual renewal premium after any negotiated discount.
- Source of business e.g. internet, broker, phone, special promotions and campaigns
- NCD/claims made record
- Reasons for lapse
- Declinatures need to be removed from exposed to risk
- Whether or not there is an open claim

***This question was generally well answered.***

(iii)

- It takes time for lapse experience to emerge because there is likely to be a range of dates between which the policyholder could call to cancel.
- Therefore it will take time to know whether or not initiative is working
- We need to know lapse rates before and after the initiative to see if it has worked
- Therefore the monitoring system needs to be in place well before the initiative starts
- To contain the delay in emergence of lapses: if there is no deadline for renewing then impose one; if there is then enforce it.
- To give timely output, the company could project ultimate lapse experience from the limited initial experience, for example by using triangulation methods.
- These methods could be unreliable because new operational initiatives might change the development pattern of lapses.
- In this case the company needs to apply judgment or a prior view of likely experience to the projection method.
- The operational initiatives might affect different groups of policyholders in different ways, which could distort an aggregate analysis.
- Monitoring could be broken down into sub-groups to help with this.
- However, this could make the emerging experience more volatile.

- Lapses could be affected by other initiatives, such as a sales promotion running at the same time or competitors' activities.
- Where possible, avoid running initiatives at the same time.
- Lapses could also be affected by changes made in past years that have affected the mix of business coming up for renewal.
- It might be possible to collect data and build a model, such as a GLM or time series analysis, that removes the effect of other factors, leaving just the effect of operational changes.
- Look at changes in call centre statistics to see if they have changed at the same time

*This question was reasonably well answered but candidates tended to focus on the issues of running initiatives at the same time as competitor activities to the detriment of other valid points. There was a general appreciation of the difficulty of assessing the effect of initiatives when a lot of other influences are present and changing.*

- 4 (i) A soft insurance market is one in which prevailing premium rates/terms and conditions generally do not allow insurers to write business (sufficiently) profitably.  
Low premium rates are not a sufficient answer, and did not receive full credit.

**Definitions should have been stronger explicitly, referring particularly to business not being sufficiently profitable. Some candidates provided a detailed discussion of the insurance cycle, which was not required and tended to obscure any valid parts of their answer.**

- (ii)
- Insurers may not realise that business is unprofitable at current rates
  - For example because of:
    - Inadequate data on claims experience
    - Poor expense allocation
    - Poor capital allocation
    - Over-optimistic persistency assumptions(or other valid examples)
  - Profitability may not be the prime driver, e.g. for a captive
  - They may write niche business that bucks the trend
  - ...or have a strong brand that allows them to keep rates higher than the market
  - They may not want to lose market share and therefore market standing
  - ...and therefore miss out on profitable business when conditions improve
  - ...or incur costs of re-entering the market
  - It can be difficult for insurers to reduce their overheads quickly when volumes reduce
  - Therefore, it may be better to keep volumes artificially high as long as each policy is still making a contribution to overheads

- Reinsurance rates may be even softer, so a gross loss may give a net profit
- Class of business may diversify against rest of the book thus keeping capital requirements low. Pulling out may significantly raise capital requirements
- Capital requirements may reduce when the premium is reduced
- There may be opportunities to cross-sell profitable lines of business
- Turning away business or exiting a line might be regarded as a sign of weakness
- The insurer might believe that an improvement in the market might be imminent
- Exiting the market may be prohibited by the regulator

The fact that the insurer might have lots of capital is not a valid answer.

(iii)

- Withdraw from an entire line of business
  - Eliminates unprofitable business provided overheads can also be reduced
  - May be seen as positive, decisive move by shareholders/stock market
  - May reduce market standing overall, leading to lower business in other lines
  - Will probably cut out some profitable business as well
  - May be difficult to re-enter market if desired later
  - Reduces diversification
  - May incur a one-off cost of change (e.g. severance)
- Continue writing same business but reduce exposure
  - Examples: Follow, rather than lead; Reduce line sizes; more RI
  - Reduces loss in a very soft market without having to withdraw
  - Shares part of the problem with the reinsurer
  - ...but may damage relationships
  - Not helpful if business is still marginally profitable because overheads are still the same
  - May fail now to cover fixed expenses
- Reduce expenses, for example through cost-cutting or renegotiating commission
  - Increases profitability overall
  - May cut investment, future opportunities etc
  - This may damage relationships with brokers
- Continue writing business but at lower premium rates
  - May make it easier to retain key clients and renew them profitably in future
  - Reduces ROCE for the business
- Increase/ stand fast on premium rates
  - Danger of business volumes collapsing
- Continue writing business but be more selective of risks
  - Maximises ROCE
  - May need more underwriting effort and therefore cost more
  - May erode relationships with brokers

***Parts (ii) and (iii) were reasonably well answered, but many candidates would have benefited from having more structure around their answer making points clearer and more succinct and in context of sub headings. The most common fault was to provide answers that did not cover sufficient points.***

- 5**
- (i) (a)  $3.03 - 2.05 = 0.98$   
(b)  $3.18 - 2.68 = 0.50$

***A number of candidates got this wrong, many dividing rather than subtracting the factors.***

- (ii) Premium / ILF (Option A) =  $20,000 / 0.98 = 20,408$   
Premium / ILF (Option B) =  $10,000 / 0.50 = 20,000$

Based on the above calculation Option A is the better option, as it gives more premium per unit of risk Credit would have been given for similar calculations and explanations.

***This question was reasonably well answered, but a fair number of candidates got the logic the wrong way round and determined that B was the better option.***

- (iii) Possible comments

- The analysis gives only a relative measure between the two layers. Both may be very poorly priced.
- The difference in profitability is only very small. Difficult to confidently recommend one over the other.
- The ILF may not be appropriate for this type of business;
- The ILF is based on losses only. Profit requirements, expense loadings etc. may differ proportionally between the two layers.
- Volatility of loss experience may be different for the two layers.
- Option B may be outside the insurer's aggregate limits.
- The higher layer may be longer-tailed and therefore attract more investment income and require a lower premium for the same expected losses.
- The fit with and cost of our own reinsurance programme should be considered
- ILF are based on unlimited coverage
- Any other sensible limitations.

***Answers given tended to concentrate on the general point of the ILF not being appropriate for the particular business being considered and missed out on the specific points. Very few candidates noticed that the difference between the two was very small or that one being better than the other did not of itself imply that either was an acceptable risk.***

- (iv) A possible alternative approach to the answer given below would be to calculate each year separately and average. This was acceptable and would have received equal credit.

Mid point of ILF period = 1 July 2009

Mid point of policy period = 1 July 2012

Inflationary period = 3 years

Inflationary factor =  $1.05^3 = 1.157625$

Inflated 100k limit = 115,763 (ILF = 1.00 still)

Inflated 200k limit = 231,525 (ILF = 1.47 still)

New ILF for 100k =  $1.00 \times 100,000/115,763 = 0.86384$

An alternative approach is to extrapolate backwards from 100,000 rather than interpolate between 0 and 100,000. This is acceptable and this answer becomes 0.936.

$$\begin{aligned} \text{New ILF for 200k} &= \frac{(231,525 - 200,000) \times 1.00 + (200,000 - 115,763) \times 1.47}{(231,525 - 115,763)} \\ &= 1.342007 \end{aligned}$$

$$\text{ILF for 100k xs 100k} = 1.34201 - 0.86384 = 0.47817$$

Assumptions

- Inflation is the same for claims of all sizes
- Inflation is same in future as in past
- Can interpolate between bottom 2 ILFs
- Can validly extend ILF below the lowest value
- Uniform incidence risk over 3 year contract

*This question was reasonably well answered but the layout of results was often not logical, which was disappointing as this is straight from core reading. The presentation of results was often very unclear, which made it difficult to tell whether an answer that was different from the model solution used a valid alternative approach (which would have gained full credit), resulted from a calculation error (which would have gained appropriate partial credit) or was wrong.*

- 6 (i) Linearly interpolating to the mid-point of the policy year gives a 75% (9/12) weight on the previous date and 25% (3/12) on the next date.

<i>Year of Account</i>	<i>Interpolated GT (m's)</i>
2007	1,924
2008	1,982
2009	2,025

For the 2010 policy year any sensible assumption would have received credit provided it was justified by the candidate. For example a 0–10% increase on the basis of recent historical growth, although 10% would be well above trend and should have been accompanied by a reason that showed that the candidate was aware of this. Having stated their assumption, candidates were expected to apply it correctly.

The rest of the solution uses +5%, giving 2,127m.

*Not many candidates determined or justified an assumption to be applied for the future. Many candidates interpolated not to the middle of the policy years but to their start, which was significantly less appropriate but also required extrapolation beyond the start of the data.*

(ii) Projections

	<i>total loss</i>	<i>large loss reduction</i>	<i>non-large</i>	<i>development factor</i>	<i>ultimate non-large</i>
2007	3,317,000		3,317,000	1.0526	3,491,579
2008	8,600,000	4,500,000	4,100,000	1.6667	6,833,333
2009	15,000		15,000	2.2222	33,333

*This was generally well answered, many candidates getting full marks.*

- (iii) Using the BF method with exposure measure GT  
Alternative methods were acceptable, such as using an expected value. However, to be acceptable a method had to be more suitable for immature years and take account of the fact that our exposure measure is GT rather than premiums or anything else.

*This was moderately well answered although not many candidates explicitly mentioned GT as exposure measure or suitability for immature years.*

- (iv) One method based on all years having equal weighting is shown below. Credit was given for:
- Realising we need to calculate an historic claims / exposure
  - Correct calculation of claims/exposure
  - Sensible selection of claims/exposure
  - Apply the selected ratio to the projected exposure
  - Appropriate assumptions

It is acceptable to leave out 2009 because it is immature but this should be explicitly justified; with 45% of claims expected to be reported it is not very immature and the fact that losses to date have been very low is not a good reason for ignoring it.



<i>Year of Account</i>	<i>GT (millions)</i>	<i>Ultimate Claims</i>	<i>Claim per million GT</i>
2007	1,924	3,491,579	1,815
2008	1,982	6,833,333	3,448
2009	2,025	33,333	16
<b>Total</b>	<b>5,931</b>	<b>10,358,245</b>	<b>1,746</b>
		<b>Selected</b>	<b>1,746</b>
2010 (Projected)	2,127	<b>3,713,742</b>	1,746

A simple average is acceptable for full marks, but examiners were looking for a sensibly justified approach.

*This question was generally well answered.*

- (v) Two methods are shown below. Credit was given for either.

<b><u>Remaining large claim</u></b>	4,500,000
<b>Method 1</b>	
Number of years	3
Claims per year	1,500,000
Large Loss	1,500,000
<b>Method 2</b>	
Historical total GT	5,931
loss/exp year	$4,500,000/5,931 = 759$
2010 Exp	2,127
Large Loss	1,613,809

Marks were deducted if 5 million was used without adjustment.

Candidates may have interpreted “loading” as either a proportionate loading or a rate per exposure year; either was acceptable.

Candidates might have spread the loading over more years if they justify this, but spreading over fewer years was not given full credit.

The important things in this question were the use of 4.5 million and properly-argued spreading.

This is a prime example of many approaches being correct. The key thing is for the candidate to explain their assumptions.

*This question was generally well answered.*

- (vi) (a) All historical claims should be trended for inflation onto 2010 terms
- (b) Historical claims which were just below the deductible may be above the deductible after trending  
Hence historical claims may be understated  
This can be solved by using individual claims from the ground up.

***Many candidates could have been more explicit that historical claims may be understated. Many candidates talked at length about inflating the XS point but this was not required.***

- 7** (i) Policy data
- Class of business
  - Dates on cover.
  - Policy limits and excess points (current and historic).
  - All other rating factor and exposure measure details
  - Historical exposures
  - Any changes to rating factors during the period.
  - Premiums charged.
  - Type of coverage and details of any exclusions.
  - And any changes to coverage historically.
  - Location of risk
  - Currency of premium
- No credit for things like policyholder name that are not part of the analysis
- Claims data
- Date of claim event.
  - Whether the claim is open, closed or reopened.
  - Date closed (if applicable).
  - Date reported.
  - Dates and amounts of payments.
  - All claims from ground up.
  - Payment type; for example, indemnity cost, lawyers' fees and adjustors' fees.
  - Dates and estimates, if they exist, of amounts outstanding.
  - Rating factor details at time of claim [no credit if changes to rating factors also mentioned in policy data].
  - Type of claim.
  - Type of peril.
  - Policy number/code to link to policy information.
  - Currency of claims
  - Cause of loss
- No extra credit for mentioning claims link to policy as well as policy link to claim.
- No credit for unique claim ID since not needed for price.

Other data

- Clear definition of all data fields (metadata).
- Expected volumes, premium sizes and mix under the new panel.
- Details of other underwriters expected to participate.
- Dates when rates will be in force.

***This question was generally well answered.***

(ii) “Sources” can reasonably be interpreted as “causes”.

Errors

- Data integrity or classification errors can cause policies & claims to be allocated to the wrong risk groups and distort the analysis,
  - leading to incorrect rates.
- For example:
  - Claim details recorded against the wrong claim.
  - Link between claim and policy information incorrect or inconsistent.
  - Risk or policy condition details at the time of claim incorrectly provided as the risk details at some other point in time.
  - Incorrect claim type or cause.
  - Unclear claim type e.g. water damage may be flood, burst pipe, sprinklers...

Credit would be given for valid alternatives

- Missing data/blank fields
- Claim dates and amounts could be incorrectly provided,
  - which would cause allocation of claims to the wrong period and distorted development/payment patterns.
- For example:
  - Notified dates instead of accident dates.
  - Where the accident date is difficult to determine, such as liability and subsidence.
  - Incorrect payment dates/amounts.
  - Changing basis for case estimates .

Credit would be given for valid alternatives

- Since B is terminating the arrangement with S, S may take little care over data quality or may withhold some data.
- The precise meaning of data definitions could be misinterpreted by B, such as exactly what is included in premium or treatment of return premiums.

Distortion

- If claims are not coded at a low enough level (e.g. type or cause) then a change in the mix of business could distort claims development patterns.
- Inflation of claim payments may distort the monetary amounts being used in claims data analysis unless the raw data is adjusted or the estimation method can make a suitable allowance.
- Changes in claims handling practices over time can distort statistics and development patterns/
- For example:
  - Recognising a claim.
  - Recording nil claims.

- Marking a claim as settled.
- Delays & backlogs.
- Credit would be given for valid alternatives
- Unusual features in the period being considered can distort the analysis, such as large claims or catastrophes.

***There was reasonable coverage of data errors and blank fields, but distortions were not well covered. Poorer answers tended to be too brief.***

(iii)

- U may wrongly decide to participate or not.
- U might make a wrong decision on the need for a rating review after comparing actual experience with expected.
- This might be because:
  - U has modelled expected experience incorrectly.
  - U had to leave a wide margin of error in monitoring, given the uncertainties in the data.
- If there is distortion of the true distribution of business or claims amongst risk groups then U might make a wrong decision on whether to accept or decline particular types of risk.
- As a result, U could suffer underwriting losses through a high panel share of unprofitable business or a loss of potentially profitable panel share.
- If panel share is much lower than expected then U may not be able to cover fixed expenses of participation.
- Antiselection is very likely if the rating structure is inadequate, since the panel arrangement enforces competition purely on price between underwriters.
- It may also be difficult to recover any lost profits after the first year of underwriting each policy, since the business is rebrokered at renewal, especially in competitive classes such as these.
- It could lead to bad reinsurance decisions
- Or bad capital decisions
- Or other bad management decisions
- Exposure measures may be calculated wrongly
- Ultimately this may lead to pricing wrongly

***Answers often concentrated on prices being too low or too high and on anti-selection, to the exclusion of other points. In addition the answers on these points did not go into sufficiently well explained detail in many cases. The most fundamental point – that U may make the wrong decision on whether or not to participate – was rarely mentioned.***

(iv)

- Take a prudent view of future experience and reflect this in the pricing structure.
- For example:
  - Conservative assumptions in models.
  - Explicit loadings for uncertainty in pricing models.
  - Fully loaded expenses.

Credit would be given for valid alternatives.

- Examine the sensitivity of the models to assumptions, particularly looking at whether it drives a decision on whether to participate.
- Request B to carry out a “what if” analysis of a draft rating structure and set of decline rules to see what business would be won at what price.
- Consider declining sole traders or only writing a subset of these risks until actual experience becomes available.
- Consider only accepting liability covers with low limits & exposures until actual experience becomes available.
- Request details from B of the performance of business that U declines, to assess whether decline rules can be relaxed.
- Benchmark by using data from similar lines of business already written as a cross-check on the experience supplied by B or to help set rates.
- Put in place monitoring of key statistics, such as volumes, premiums, mix of business and panel share to spot possible problems early.
- Ensure that U can model and change rates quickly and that B agrees to implement them quickly.
- Have a profit sharing arrangement so that B has a financial interest in the success of the underwriters
- Checks on data input
- Use more reinsurance, reducing the retention to reduce risk.

***Answers tended to concentrate on benchmarks and internal/external data to the exclusion of other points. Even the most basic actuarial principle of adding a margin to the basis was missing in many cases.***

## 8 (i) Data

- It should be established first whether the data are correct.
- Examples:
  - Whether the numerator and denominator of the claim frequency correspond.
  - Whether treatment of nil claims is correct.
  - Statistical quality of data (is there enough?)
  - Policyholders may falsely claim to have the appropriate alarms
  - It is possible that some customers installed their alarms after they were burgled and this distinction may not have been picked up

### Time period

- The period of experience used may have a large effect on the figure.
- Examples:
  - Time period might not correspond with that used for pricing (e.g. too old to be relevant or too recent to have shown in pricing yet)
  - Time period may be very short and statistically unreliable.
  - The periods may not be consistent for both sets of policies

There is more to price than claim frequency

- (no credit for saying theft is not the only peril)
- The cost of theft claims depends on claim amounts, not just frequency.

- So it is worth looking at how average claims cost varies by type of security.
- The customer price may change differently from claims cost across levels of a rating factor if the company does not use constant loadings for profit etc across the book.
- Even if the claims cost is lower for lower security measures, the company would probably want to charge premiums that are intuitive to sellers and that do not encourage adverse policyholder behaviour.
- People without alarms may have lower-valued contents and may therefore may be less tempting as burglary prospects or be less likely to submit a claim.
- There may be a degree of moral hazard: people with alarms may be less careful in other ways.

#### Modelling

- The exposure for this type of security measure might be low in the data used for pricing, so worth looking at whether it has been smoothed judgmentally by the modeller.
- The Claims Director appears to be quoting a one-way analysis from the data and comparing it with the output of a GLM.
- A one-way analysis can misstate the true relativities if good experience for better security measures is masked by a correlation with another factor that results in poor experience, such as the location of the property.

***Most candidates got marks for noting that other rating factors interacted in a complex way with burglar alarms and that severity was an issue, usually with well-explained examples. More general points such as “we should investigate” were missed.***

(ii)

- A two-way analysis by each combination of the level of security together with another factor.
  - This would show key statistics such as exposure and theft claims frequency in graphical form for ease of understanding.
  - The goodness of fit of the model to the data should be investigated.
  - Valid example of possible factors, such as by security and postcode area so it can be seen how they tend to move together.
- A correlation analysis that shows the extent to which claims frequencies for levels of different rating factors tend to move together.
  - For example, Cramer's V statistic, where values close to 1 for level of security would indicate a high level of dependency with other rating factors.
  - The results would be presented as a matrix of values for each combination of rating factors.

***This question was generally poorly answered. The critical points are that analysis needs to cover the interaction between factors and identifying the methods for these analyses.***

- 9 One possible approach is shown below, but candidates may have approached this question from the opposite direction. That is, they went straight to (b) and worked out the credibility on the basis of an  $x\%$  probability of being within  $y\%$  of the true mean. If they looked to show that the actual number of claims is less than the number needed for full credibility and conclude from that that it is appropriate to give only partial allowance for own losses then that would have received appropriate credit (subject to the calculation being right). They needed to complete the first half of the answer to get the credibility-weighted claims rate.

- (a) The number of claims in the period is probably best represented by the Poisson distribution, but with this many claims it is reasonable to use a normal approximation.

The expected number of claims is  $1,000 * 0.16 * 9/12 = 120$

Assume that claims are likely to be evenly spaced through the year. (Many candidates mentioned that in fact this was far from certain.)

The standard deviation is the square root of this, or 10.954.

The actual number of claims is 11 below expected; making a continuity correction we use 10.5, which is 0.959 standard deviations.

The probability of a result this low is  $\Phi(-0.959) = 0.1689$ , or 16.9%.

The probability of a result this far from the mean is 34%.

This means that the result is rather more probable than is normally considered appropriate to allow full credibility in setting premium rates. However, it is extreme enough that it would be normal to allow some influence of the actual experience.

***This question was poorly answered with very few candidates carrying out the above analysis. A significant number of candidates questioned the background they were given in the question, which they should have taken as assumptions.***

- (b) It may be appropriate to allow full credibility when the probability of being within 10% of the mean is 90%. (Any other sensible combination would have been accepted. This is probably the most generous to be allowed without any caveats.)

This means that the number of claims for full credibility is given as follows. A number of choices for the combination of probability and tolerance are given.

Probability	90%	95%	90%	95%
Tolerance	10%	10%	5%	5%
	$[\Phi^{-1}(\frac{1}{2}(1+0.9))/0.1]^2$	$[\Phi^{-1}(\frac{1}{2}(1+0.95))/0.1]^2$	$[\Phi^{-1}(\frac{1}{2}(1+0.9))/0.05]^2$	$[\Phi^{-1}(\frac{1}{2}(1+0.95))/0.05]^2$
=	$[1.644584 * 10]^2$	$[1.955996 * 10]^2$	$[1.644584 * 20]^2$	$[1.955996 * 20]^2$
=	271	384	1,082	1,537

The expected number of claims is 120, which gives a credibility factor of

	$(120/271)^{0.5}$	$(120/384)^{0.5}$	$(120/1082)^{0.5}$	$(120/1537)^{0.5}$
=	0.665	0.559	0.333	0.279

The actual reported rate of claims is  $109/1000 * 12/9 = .145$

The credibility-weighted rate of claims is therefore

$(0.145 * 0.665 + 0.16 * 0.335)$	$(0.145 * 0.559 + 0.16 * 0.441)$	$(0.145 * 0.333 + 0.16 * 0.667)$	$(0.145 * 0.279 + 0.16 * 0.721)$
= 0.150	0.152	0.155	0.156

***This question was reasonably well answered when it was attempted, although answers could have been much better laid out into logical steps. Too many candidates decided that credibility theory was not an appropriate approach, despite being told to use it, and did not answer the question. The point of the question was to determine whether or not candidates could apply credibility theory, not to see whether or not they could evaluate its appropriateness in a particular case. Some used apparently arbitrary weighting factors.***

## 10 Financial reinsurance and co-insurance do not get any credit in this question.

The company is said to be well capitalised, but it is small. Therefore it may use quota-share reinsurance for diversification.

or if it is a recent entrant to a class of business.

It might take surplus reinsurance, in which it can choose the level of its retention for each risk, in order to defray larger risks.

It will almost certainly take out risk excess of loss insurance on its whole book. This refunds every claim that exceeds a certain amount (the retention) up to a maximum higher amount (the limit). The limit should be chosen so that it is very unlikely that any single claim will exceed it. This will also stabilise losses, protect against insolvency and may give the company access to technical help, which is especially important for a small company.

It will also need catastrophe excess of loss for the property book. This gives similar cover to excess of loss, but relates to events – catastrophes – that cause a large number of claims but not necessarily any claims that are large in themselves. Such a policy contains an “hours clause”, defining the maximum period of time over which claims may be added for this cover.



The liability book may be covered by aggregate excess of loss, under which claims from the same cause may be aggregated for an excess-of-loss claim, without having to occur within the same short period.

The company may seek stop-loss insurance, covering all or part of the book of business from an unusually high loss ratio; generally claims in excess of a specified loss ratio up to a loss-ratio limit would be covered. Such cover is often difficult to obtain, and therefore may not be held.

The company may take out an industry loss warranty.

In which its recoveries are based on losses to the industry as a whole.

***This question was reasonably well answered although candidates missed easy marks for not describing the cover in sufficient detail.***

## **END OF EXAMINERS' REPORT**

# EXAMINATION

11 October 2010 (pm)

## Subject ST8 — General Insurance: Pricing Specialist Technical

*Time allowed: Three hours*

### **INSTRUCTIONS TO THE CANDIDATE**

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 10 questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

### **AT THE END OF THE EXAMINATION**

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

*In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.*

- 1 A general insurance company is using a generalised linear model to set risk premium rates for a book of business. The rating factors available are as follows:

<i>Rating factor</i>	<i>Possible values</i>
Age attained	16 to 120
Gender	M or F
Employment type	A, B, C, D or E

The model uses a linear variate for age attained.

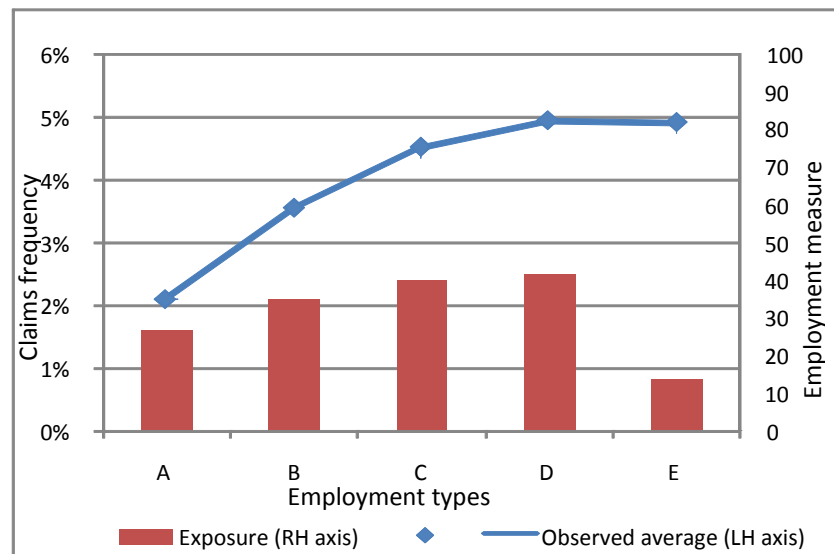
The following are three observations in the data:

<i>Observation</i>	<i>Age attained</i>	<i>Gender</i>	<i>Employment</i>
1	18	M	D
2	55	F	A
3	92	M	E

- (i) Construct for the model:
- (a) a vector of parameters
  - (b) a design matrix including a row for each of the three observations
  - (c) a set of definitions for the columns of the design matrix

[3]

The modeller wishes to improve the model for claims frequency by reducing the number of parameters. The following chart illustrates the data relating to employment type.



- (ii) Describe suitable methods for reducing the number of parameters.

[2]

The modeller is concerned that the linear fit of the age variate for very young and very old ages may be unreliable because the data is sparse in these ranges.

- (iii) Suggest a method of grouping the data that could improve the reliability of the model.

[1]

[Total 6]

**2** A general insurance company is reviewing the expense loadings in its premium rates.

Discuss the difficulties that are likely to arise when subdividing expenses between new business and renewals. [4]

**3** (i) Describe the cover given under risk excess of loss reinsurance. [2]

(ii) Explain “reinstatement” in the context of risk excess of loss reinsurance. [4]  
[Total 6]

**4** A general insurance company is about to write commercial property insurance for the first time.

(i) State the reasons for the company to monitor business written. [3]

The Managing Director has requested a regular report on premium rate changes to assist with monitoring profitability and has suggested the following as possible definitions:

(a) change in average premium per unit of expected loss calculated considering each individual risk written

(b) change in average premium per unit of expected loss calculated considering a basket of risks representative of the portfolio

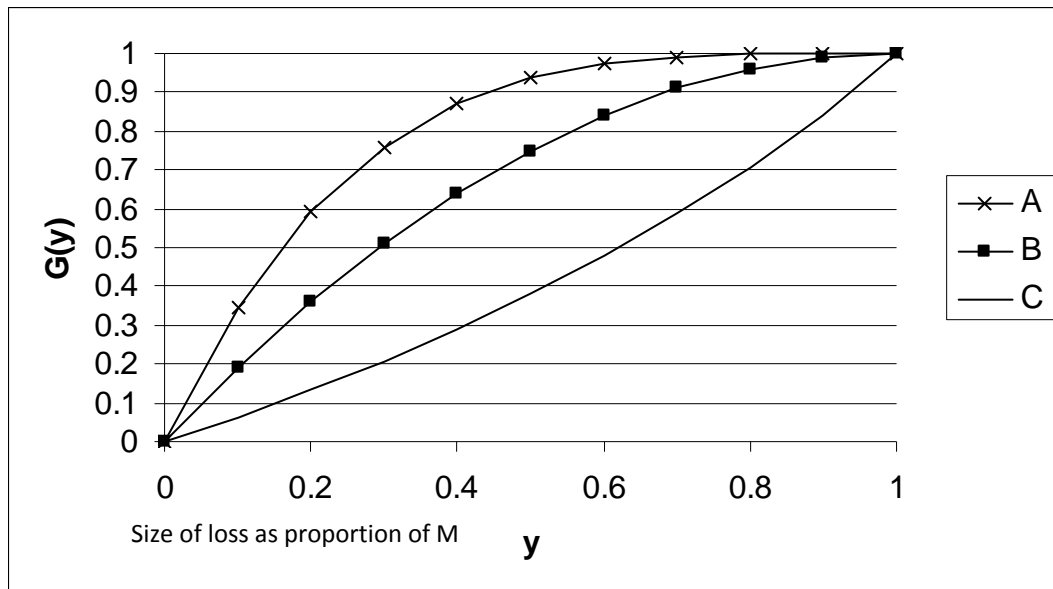
(c) the class underwriter’s overall view of premium-rate changes

(ii) Explain the relative merits of these three definitions. [6]  
[Total 9]

- 5 The chart below shows three exposure curves.  $Y$  is a random variable representing the size of loss as a proportion of the total sum insured ( $M$ ). The curves are used for losses only.

The exposure curve is defined as  $G(x) = \text{LEV}(x) / E[Y]$ , where  $\text{LEV}(x)$  is the limited expected value function:

$$\text{LEV}(x) = \int_0^x (1 - F(y)) dy, \text{ where } F(y) \text{ is the cumulative density function of } Y.$$



- (i) State the key assumption about the relationship between  $Y$  and  $M$ . [1]

Assume that you have calculated the ground-up premium for a property risk. You now want to use the curves above to calculate an appropriate premium rate for a layer between 0 and  $M/2$ .

- (ii) Explain the relationship that you would expect between premiums for this layer calculated using curves A and B, without doing any calculations. [1]
- (iii) Describe briefly how you would expect the distributions of claims size underlying curves A and B to differ. [1]
- (iv) Describe the approach to selecting the most appropriate curve for the rating exercise. [3]
- (v) Comment on whether or not curve C is likely to be appropriate for an exercise of this type by considering the shape of a curve in which only total losses were possible, or otherwise. [2]

[Total 8]

**6** An analyst at a general insurance company that writes personal lines business in the UK is modelling the cost of claims for the purpose of pricing.

(i) State the purpose of using spatial smoothing for the full postcode rating factor. [1]

(ii) Explain whether distance-based or adjacency-based methods would be more suitable for the following types of claim:

- (a) windstorm claims on household buildings
- (b) theft claims on motor

[3]

The analyst is considering using an adjusted distance-based method for flood claims that includes height above sea level and distance from the coast in addition to latitude and longitude.

(iii) Discuss the advantages and disadvantages of this proposal. [2]

The analyst has fitted a model that uses the spatially-smoothed postcode as a factor.

(iv) Suggest diagnostics that could be used to test whether the extent of smoothing is appropriate. [2]

[Total 8]

**7** An underwriter has been asked to quote a premium for the 2011 contract for professional indemnity insurance for an accountancy firm. The broker has provided data on claims on the policy originating from the last three underwriting years. In each of these years the policy had a per-claim deductible of 100,000. For the coming year this is being raised to 150,000.

The underwriter is proposing a premium of 1,450,000 for the coming year and has produced the following spreadsheet.

<i>Underwriting Year</i>	<i>Number of Claims</i>	<i>Aggregate Claims</i>	<i>Increase in Deductible</i>	<i>Claims under New Deductible</i>
2007	2	2,600,000	50,000	2,550,000
2008	3	1,500,000	50,000	1,450,000
2009	1	400,000	50,000	350,000
Total Claims				4,350,000
No. of Years				3
Average Claims per Year				1,450,000
Proposed Premium for Next Year				1,450,000

Discuss the underwriter's analysis and how it might be improved. [11]

- 8** An insurance company needs to price an insurance policy for the property portfolio of a large commercial enterprise. The coverage is \$5 million xs \$25,000 per loss. The company has insured the risk for many years, in which time the coverage has always remained the same.

The company has decided to price the layer based on the experience of this risk. Below is an extract of policy claims from the claims department for the \$5 million xs \$25,000 layer. The amounts have been restated using the current exchange rate.

<i>Claim Ref</i>	<i>Peril</i>	<i>Claim Status (Open/Closed)</i>	<i>Claim Amounts (\$) cumulative to date</i>		
			<i>Paid</i>	<i>Outstanding</i>	<i>Incurred</i>
675	Snow	Closed	35,000	—	35,000
676	Flooding	Closed	20,000	—	20,000
677	Wind	Closed	340,000	—	340,000
678	Fire	Closed	5,000,000	—	5,000,000
679	Wind	Closed	750,000	—	750,000
680	Theft	Closed	30,000	—	30,000
681	Tornado	Open	50,000	10,000	60,000
682	Flooding	Open	10,000	5,000	15,000
683	Fire	Open	—	25,000	25,000
684	Fire	Open	—	25,000	25,000
685	Flooding	Open	—	25,000	25,000

- (i) Comment upon the appropriateness of using the open and closed claims data for pricing the policy. [4]
- (ii) Suggest how the claims data might be adjusted for pricing the following policy options.
- (a) Increasing the excess to \$50,000
  - (b) Lowering the excess to \$10,000
  - (c) Excluding flood coverage
  - (d) Including terrorism coverage (this was not previously covered)
  - (e) Lowering the limit to \$1m
  - (f) Increasing the limit to \$10m

[7]

[Total 11]

- 9**
- (i) List the principal covers that would be included in comprehensive motor insurance. [2]
  - (ii) State, for each cover under part (i), whether or not it would normally be included in non-comprehensive motor insurance. [1]
  - (iii) Describe the main benefits and insured perils of each cover listed in part (i). [6]
  - (iv) Explain how inflation may be expected to affect the cost of claims of each of the cover listed in part(i) and the types of inflation index that may be useful in projecting claims. [6]
- [Total 15]

- 10** A general insurance company markets and underwrites direct household and motor business. A marketing manager has proposed a change to the product whereby the compulsory policy excess will be waived for any claim caused by a third-party criminal act. The manager has also suggested that the change could be made to existing policies at their next renewal.
- (i) Explain the advantages to the company of the manager's proposals for new and renewing policies. [4]
  - (ii) Discuss the additional uncertainties involved with the pricing of this extra coverage. [8]
  - (iii) Suggest the measures that the company might implement to mitigate the uncertainties in part (ii). [10]
- [Total 22]

**END OF PAPER**



# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

September 2010 examinations

### **Subject ST8 — General Insurance: Pricing Specialist Technical**

#### **Introduction**

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

T J Birse  
Chairman of the Board of Examiners

January 2010

- 1 (i) The solution below uses a base-level parameter  $\beta_0$ . Other equivalent formulations are valid, provided that they have the correct number of parameters.

$$(a) \begin{pmatrix} \beta_0 \\ \beta_\alpha \\ \beta_M \\ \beta_A \\ \beta_B \\ \beta_C \\ \beta_D \end{pmatrix}$$

$$(b) \begin{pmatrix} 1 & 18 & 1 & 0 & 0 & 0 & 1 \\ 1 & 55 & 0 & 1 & 0 & 0 & 0 \\ 1 & 92 & 1 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Here, the examiners were looking for correct allocation of rating factor values to the vector in (a).

- (c)
- Column 1 is the base level
  - Column 2 is age attained
  - Column 3 means “Is male?”
  - Columns 4–7 mean “Is employment A?” and so on through to D

Few candidates remembered to include the base level (intercept term), despite there being a similar example in Core Reading. Over-parameterisation was also a common error (e.g., five employment types).

- (ii)
- Replace employment type categories with a variate and fit a curve,
  - Using this method, each level of employment type is assigned an x-value and a polynomial is fitted.
  - Group employment types together.
  - In particular, D and E look good candidates (E has low exposure and they have similar frequencies).
  - Remove employment type from the model completely.

Most candidates mentioned grouping, but few considered the other alternatives. Candidates who mentioned curve fitting often went into too much detail.

- (iii)
- Group together young ages,

- and also old ages,
- ...fitting a constant frequency within each.
- Retain the linear fit where there is sufficient data.
- Join to the grouped values in a piecewise-continuous fashion.

*Many candidates did not mention that the linear fit should be retained over the mid-age range.*

## 2 **Allocating expenses**

- For an accurate expense analysis, accurate cost data is required.
- This needs to be split by activity/function.
- ...and whether costs depend on volume of business, premium size or some other element.
- However, accurate data may not be available at this level.
- Many functions are central or there is no obvious way of splitting costs.
- Approximations may be needed, such as time-sheet sampling and pro-rating by headcount/floor space.
- These allocations can be inaccurate...
- ...and become out-of-date quite quickly.

### **Loading into the rates**

- If the expense splits are not accurate, the modelled costs may not reflect actual costs if the balance between new and renewal business changes.
- The expenses for new business are likely to be higher than for renewals, so the theoretical premium is probably higher for new business.
- However, this may mean that new business premiums are uncompetitive.
- So, renewal business may need to subsidise new business.
- This requires assumptions on sales and persistency, which introduce uncertainty.

*Most candidates had a grasp of the concepts involved, but many struggled to generate a wide enough range of points.*

## 3 (i)

- Risk excess of loss covers an insurance company against the cost of individual large claims.
- If a single large claim occurs then the reinsurer reimburses the insurer for the amount above a stated excess point, usually up to an upper limit.
- The excess point and upper limit may be fixed, or indexed, as specified in a stability clause.

*Many candidates stated that the cover was for a single risk, i.e. facultative. Only a few mentioned the stability clause.*

## (ii)

- The restoration of cover following a claim.
- There is often a limit to the number of times that cover may be reinstated,

- ...which means that there is a limit to the total recovery under the reinsurance.
- The terms of reinstatement will be specified in the contract.
- Once agreed, they are automatic and obligatory on both parties.
- To restore cover it may be necessary to pay a reinstatement premium.
- This will usually be equal to the original premium of the reinsurance, multiplied by the proportion that the reinsurance recovery bears to the cover
- The amount of the premium may be pro-rated to the remaining term of the contract.

*Some candidates stated that reinstatement is a form of retrospective experience rating, which is not strictly true because it is replacing cover that has been exhausted, rather than recalculating the premium per unit risk. Some students seemed to be confused about the distinction between the reinstatement and the reinstatement premium. It is not correct to say that the reinstatement is the amount needed to restore cover after a claim.*

## 4

### (i)

- Assess performance of the business against the company's goals,
- ...in order to inform planning and decision-making.
  - Examples:
    - underwriting quality for different underwriters
    - business from different sources
    - profitability
    - expense experience
    - sales volumes
    - renewal/cancellation/movement experience
    - operational performance (staffing, expertise etc)
- Assess and manage the level of risk inherent in the portfolio,
- ...in order to inform capital requirements,
- ...and reinsurance strategy.
  - For example, to keep track of aggregation issues and ensure that the company is not overexposed to particular types of loss.
- Gain information about the state of the market and the company's competitive position.
- Satisfy regulatory requirements for monitoring and reporting.
- Influence the market (competitors, trade bodies and authorities) by publishing results of monitoring.
- As a by-product, to input to the reserving process.
- To compare actual with expected results from a model (as part of the actuarial control cycle).
- Gain exposure information for reinsurers.

*The solution here was mainly from Core Reading and many candidates scored well.*

- (ii) (a)
- Many factors affecting the expected loss can be taken into account, making the method quite accurate.
    - In particular, it allows for changes in the make-up of the book, such as business mix, lapses and new business.
    - For this reason, it may be required by reinsurers or regulatory underwriting standards.
  - As a spin-off, the absolute premium rate is calculated in addition to the rate change.
  - Data- and calculation-intensive, so could be laborious, or data may not be available.
  - It may be difficult to quantify the effect of “softer” factors, such as changes in the quality of risk management procedures.
  - Provides the best data for pricing and measuring profitability, particularly by source and type of business.
- (b)
- Less data-intensive than (a), so probably cheaper and quicker.
  - Relies on the rate change for the basket of risks being representative of the portfolio.
  - This may be an unsafe assumption for large commercial properties that are individual in nature.
  - The constituents of the basket or the weightings used will need to be adjusted over time.
- (c)
- Allows for “softer” factors in the rates.
  - The effect of various factors on the rates is subjective, depending on the particular business handled by that underwriter.
  - The definition of pure rate change might be misinterpreted or miscalculated.
  - This can lead to inconsistencies,
  - ...over time/across classes of business/between underwriters.
  - Open to possible bias.
  - Far cheaper/quicker to “compute”.

*The better-scoring candidates structured their answers around the different options and explained their points (as required in the question).*

- 5**
- (i) Y is independent of M.
- (ii) The rate will be higher using curve A because a greater proportion of claims fall into the band of losses that are covered.
- (iii) A has a greater percentage of smaller claims proportionally to risk size / sum insured.

(iv)

- Find out where the curves came from, that is who produced them and how. This will give us an idea to their credibility.
- Find out what the two curves have been built for (for example, occupancy, location etc.).
- This may match the type of property we are rating.
- If not, talk to underwriters/other experts to see which is the closest match in terms of claims distribution.
- It may be thought that none are that appropriate.
- If this is the case we may need to:
  - use curve from another similar exercise
  - adjust these using experience/judgment
  - build our own

(v)

- Exposure curves should be concave or the straight line  $y = G(y)$ .
- The straight line occurs where the only type of loss is a total loss.
- As we start to allow partial losses the curve will move above the diagonal.
- Hence it is impossible to get a proper curve below the diagonal.
- Therefore, C cannot be a suitable curve to use.

*Most candidates failed to score well on this question. In (iv), a common error was to write in detail about how to construct a curve from claims analysis, rather than the factors that should influence selection of an appropriate one. In (v), very few candidates explained clearly why C is not an appropriate curve.*

**6**

(i)

- Because full postcode has a huge number of levels, a model that includes it as a factor will feature a great deal of random noise and lack of credibility.
- Spatial smoothing is designed to improve this by allowing the relativity for each postcode level to take account of neighbouring values.

(ii)

(a)

- Distance-based is likely to be better.
- Distance does not take into account whether an area is urban or rural.
- This means there is less danger of over- or under-smoothing urban and rural areas.
- It tends to be easier to understand and implement.

(b)

- Adjacency-based is likely to be better.
- Location codes tend to be smaller in urban regions and larger in rural areas, so adjacency-based smoothing can sometimes handle urban and rural differences more appropriately for this type of peril.

- Can take account of physical barriers between regions (eg rivers).

*Answers to (i) and (ii) often appeared to confuse the purpose of spatial smoothing with rate smoothing.*

(iii) *Advantages*

- This would allow high flood risk areas to be more influenced by experience in nearby high flood risk areas than by low flood risk areas, which may be appropriate.
- In particular, height above sea level will help with riverine flood,
- ...and height and distance from the coast with coastal flood.

*Disadvantages*

- The method is more computationally intensive and complex to explain.
- The data will need to be collected and maintained for every postcode, which may be expensive and difficult.
- It may only be significantly valuable for household buildings, where location is fixed and claims amounts very high.

*Clear statements about height and distance were often missing from answers to this part.*

(iv)

- Test the model's predictiveness on out-of-sample experience, i.e. withholding a proportion of the data from the smoothing process.
- This involves comparing the model's predictions for the out-of-sample dataset with actual experience and examining whether there are systematic differences indicating a poor fit.
- A lift curve or similar examination of relativities could be used on the out-of-sample dataset to assess whether the model distinguishes adequately between high- and low-risk areas.
- The experience could be examined by time period to assess whether there is consistency over time in the areas identified as high or low risk (but this may produce excessive granularity).
- Residuals could be examined by location to identify any systematic location-based effects that have not been included in the model.
- Apply goodness-of-fit tests, as appropriate for the model used.

*Many candidates concentrated on analysis of residuals and failed to pick up marks on the other points.*

7

- It has taken into account historic claims experience.
- Simple & easy to understand.
- It is not clear what the claims data is. It may be paid or incurred. If incurred, then what basis are the outstanding reserves on: realistic or pessimistic, for example.

- Is the data gross or net of reinsurance?
- Claims should be trended forward for inflation. This will be significant in liability business as the inflation rate is often high.
- There seems to be no projection of claims for paid/incurred to ultimate including IBNR. This is long-tailed business and so this may be significant, especially but not only on the last two years.
- There is no allowance made for large losses or accumulations of claims. We need to know to what extent they are included in the data.
- We have no idea of exposure over these years. We should consider claims/exposure. We would also need to know the projected exposure for the 2011 year of account.
- A sensible exposure measure might be revenue/turnover or headcount.
- There is no attempt to identify trends in claims. Or known changes to this risk. For example, change in legislation, claims environment, type of work.
- Three years are not really sufficient for a credible analysis. Five or more years are desirable.
- 2010 is missing.
- The approach to adjusting for the increased deductible is incorrect. Such an approach assumes we have had only have one claim in each year, which is untrue.
- We would require individual claims to calculate the effects of the new deductible.
- The underwriter is proposing charging the expected cost of claims. He should load up the premium to include profit/cost of capital, expenses, commission, reinsurance costs, premium tax etc. In particular, investment income because of the long tailed nature of the class.
- The contract is completely experience rated, which might not be appropriate. Ideally, we should use data from other similar risks as well.
- We might consider a frequency-severity approach, although this is not necessarily suitable for PI.
- We also need to know if terms and conditions have changed over the years.
- Competitors' rates and point in market cycle should be considered.
- There could be currency conversion issues.
- Use last year's premium (suitably adjusted) as a sense-check against the result.

*Many candidates generated a wide range of points and scored well. However, there was no credit for belittling the underwriter's analysis.*

8

(i)

- Closed claim amounts do not usually change.
- Open claims have an estimate of outstanding reserve. The final amount may be quite different,
- ...particularly when nothing has been paid.
- Some companies may reserve (case estimates) prudently, in which case the estimates may be biased upwards.
- Some companies may put an automatic reserve on all notified claims immediately without considering likelihoods.
- There seems evidence for that here with the 25k reserves.



- All claim amounts look to have been rounded, so not sure how reliable they are.
  - Incurred amounts for open claims might not contain anything for business interruption or if they do then they may be based on unverified loss of profits.
  - There might be some losses that haven't been notified yet because of reporting delays or because the estimated amount isn't big enough yet.
  - We should analyse how open claims have moved historically,
  - ...and possibly adjust the open claims:
    - closed claims may also re-open and move
    - we should adjust for inflation
    - older claims data may be less relevant than newer ones
    - claims below excesses/deductibles may be missing
- (ii) (a)
- Remove the extra excess from each claim.
- (b)
- We can add \$15k to each of the claims.
  - However, there may be claims we do not know about below \$25k.
  - Ideally we would get all ground up claims from the insured.
  - Or make an adjustment to the claims we have based on benchmark data such as an exposure curve.
- (c)
- Remove the claims we have labelled flood.
  - Check whether the whole claim was due to flood.
- (d)
- We are introducing a new coverage so will have no historical data.
  - Need to use data from elsewhere.
  - Could also use an exposure method/catastrophe model.
- (e)
- Limit all claims to \$1m.
  - We have one such claim only. The \$5m claim becomes \$1m.
- (f)
- We need to add on additional claims between \$5.025m and \$10.025m.
  - We may not know this information for the limits claims i.e. the \$5m one.
  - Ideally we would get all GU claims from the insured.
  - or make an adjustment to the claims we have based on benchmark data, e.g. an exposure curve.

*There were no systematic problems with this question. However, the better-scoring candidates used examples from the actual claims data to reinforce their points. In (ii)(b), some students seemed to want to add \$10k onto the claims rather than the correct \$15k.*

- 9
- (i)
- (a) Own (accidental) damage
  - (b) Third-party bodily injury
  - (c) Third-party property damage
  - (d) Fire
  - (e) Theft of vehicle
  - (f) Theft from vehicle
  - (g) Windscreen
  - (h) Personal accident to the insured may be included
  - (i) Malicious damage
- (ii)
- (a) No
  - (b) Yes
  - (c) Yes
  - (d) Sometimes/usually
  - (e) Sometimes/usually
  - (f) Sometimes/usually
  - (g) No
  - (h) No
  - (i) No
- (iii) Own damage
- The insured peril is damage to the policyholder's vehicle due to an accident.
  - If the insured vehicle is damaged the insurer will pay for the car to be repaired.
  - If the car cannot be repaired then the insurer will pay the insured its market value before the damage.
  - ...and retain the vehicle.

Third party bodily injury

- The insured peril is injury to a third party caused by the insured driver.
- The insurer pays compensation to the injured victims.

Third party property damage

- The insured peril is damage to the property of a third party caused by the insured driver.
- The insurer pays compensation for the loss or damage.

Fire

- The insured peril is damage to the policyholder's vehicle caused by fire.
- The cover is the same as for Own Damage.

#### Theft of vehicle

- The insured peril is theft of the entire vehicle.
- or theft of the contents of the vehicle.
- and damage to the vehicle caused by attempted theft.
- If the vehicle is not recovered, the insurer will pay the current market value before the loss.
- If the contents are not recovered, the insurer will pay the cost of replacement, up to an upper limit.
- If the vehicle is damaged during theft, the insurer will pay for the cost of any repairs.

#### Windscreen

- The insured peril is damage to windows.
- The insurer will pay for replacement or repair.

#### Personal accident

- The insured peril is injury to the insured driver in an accident.
- The insurer will pay fixed benefits depending on the nature of the injuries.

#### (iv) Own damage

- Covers both parts and labour.
- Wage costs tend to increase more quickly than cost of parts.
- A suitable index is between a wage index and price of good index.

#### Third party bodily injury

- Amounts paid for compensation of injury tend to increase more quickly than price or wage indices.
- This appears to be because of a general trend towards more generous compensation for injury, especially serious injury.
- Occasional legislative changes tend to have one-off effects on the level of compensation.
- E.g., Ogden or Courts Act.
- A suitable index would be a wage index with a moderate addition.
- For structured settlements/periodic payments, an index based on cost of medical care would be needed.

#### Third party property damage

- Very similar to own damage.

#### Fire

- Here there will be a higher proportion of total losses than with own damage.
- So an appropriate index would be closer to the price of goods.

#### Theft of vehicle

- Very similar to fire.

#### Theft from vehicle

- This covers mainly replacement of stolen items.
- so an appropriate index will be close to a price of good index.

#### Windscreen

- Very similar to own damage.

#### Personal accident

- No inflation, as benefits are fixed.

*Many candidates lost marks by failing to separate the covers in later parts of the question. Other particular problems noted in answers were:*

- *Failure to distinguish between bodily injury and property damage liability covers*
- *Insufficient precision in descriptions of the benefits of cover*
- *Statements that for third party covers the insured gets money from the insurer to pay compensation to third parties*
- *Statements that if a car were written off or stolen the insured would receive "new for old".*

### 10 (i)

- The proposal would be expected to stimulate growth in sales volumes, possibly due to:
  - it being a unique offering that attracts business from competitors
  - customers placing a high value on it, so the company can charge more for it and still lift volumes.
  - the feature being exciting for sellers, encouraging them to promote it
- Volume growth will allow fixed expenses to be spread over a larger book.
- Extending it to renewals should improve retention rates now.
- Extending it to renewals will improve consistency with new sales.
  - This would help to avoid existing policyholders becoming disgruntled or “churning” to a new policy at renewal.
- It may reduce the incentive for claimants to inflate claims in an attempt to recoup the policy excess.

- It may attract more low risk policyholders who consider themselves unlikely to claim as a result of their own actions.
- It may result in higher policyholder satisfaction with the product.
  - which may lead to better retention rates in the future.
  - and cross-selling opportunities.

*Some candidates wasted time here by giving disadvantages.*

**(ii) Data problems**

- There may be a lack of information on claims below the excess point to use for rate reviews if the company has not offered a nil excess before on this product.
- The quality of any data for an incident below the excess point that has been recorded may be lower quality because it did not lead to a claim.
- Claims data may not be available in enough detail to analyse separately the experience for the “criminal act” types of claim.
- There may be systematic bias in historic claim amounts (eg artificially low case estimates) that would distort the analysis.
- The pricing analyst may make a mistake when adjusting historic data for use in rating.

**Random error**

- Depending on the definition of criminal act there might be only a small number of claims where the excess is waived, which could lead to over-fitting of claim frequency in rating models.
- There might be a catastrophic event (e.g., a riot), concentrated in a particular area that could distort claim frequencies and average claim amounts, leading to over-fitting of rating models.

**Model error**

- There may be insufficient data for a hold-out sample, particularly in the early days of the initiative, which will make it difficult to validate the model.
- Newer, more relevant data will be incomplete, whereas older, more complete data will be less relevant, which makes it difficult to decide which data to pick for the model.

**Adjustment of experience**

- When rates are next reviewed, claims experience will need to be adjusted for differences that are very difficult to predict, such as:
  - More claims below the old excess point
  - More claims just above excess point where previously the policyholder would not have bothered claiming
  - Lack of excess could encourage a lack of care

- Lack of excess could encourage fraud (e.g. giving crime as the cause for non-criminal claims)
- Rating factor relativities could be invalidated by the change, particularly since level of excess is probably used as a rating factor.
- Development factors may alter due to change. This may affect the IBNR loading.

### **Market conditions**

- Any assumed uplift in sales volumes could be over-optimistic, depending on the point in the market cycle.
- The initiative could be copied by competitors, so benefits are curtailed.
- The need to charge more for the product could make it less attractive than assumed.
- Legal or regulatory challenges or market pressure could cause the company to allow more zero excess claims than planned (ie, not force as many policyholders to prove that claims are crime-related).
- Sellers and claims advisers may not understand the policy conditions consistently, resulting in unpredictable experience.
- The coverage or price of outwards reinsurance is uncertain.

### **Portfolio movements**

- If the company fails to allow an appropriate cost of risk in the premium then it could be subject to antiselection.
- The larger number of claims could cause a increase in claims expenses.
- The change in mix of business may mean the expense loadings become inappropriate and need to be reviewed.
- The effect on new business and renewal volumes is uncertain so the cross-subsidy between new business and renewal may be invalid.
- The additional costs associated with marketing and administration of the changes are uncertain.
- It will take a long time for the full effect on all renewals to be identified and there will initially be a mixture of cohorts renewing at any one time, some with the lower excess and some without.

### **(iii) Data problems**

- If there are any other products with a nil excess the company could use this data with suitable adjustments to help estimate the effect of removing the excess.
- There may be some external data available to help validate the distinction between “criminal act” and other claims experience (eg overall frequencies or amounts).
- If “criminal act” claim types cannot be distinguished then at a minimum the company should change systems and procedures so that this is fixed for the future.

- Carry out peer review and checking of data to spot any errors in data manipulation or adjustment.

### **Random error**

- Take care in modelling to avoid over-reliance on small exposures by grouping and smoothing experience.
- Conduct peril level analysis to identify unusual events and employ appropriate smoothing to claim frequencies and amounts.

### **Model error**

- Build a model of expected claims distribution by size and type and monitor regularly the observed experience against expected to help assess whether rating adjustments are needed.
- Avoid over-reliance on immature data with small exposure by using judgmental smoothing adjustments.

### **Adjustment of experience**

- Separate claims under the two sets of policy conditions, adjust the claims under the old conditions for the estimated effect of the nil excess and recombine the data to get a more reliable run-off pattern.
- Pay particular attention to the factors that are likely to change the most, such as policy types with high crime risk or high compulsory excesses.
- Consider restricting availability of the nil excess “subject to status”, i.e. depending on characteristics of the policyholder, the property/vehicle or claims history.
- Insist on proper precautions such as robust locks for household, alarm system for motor.
- Voice recognition to pick up on fraudulent attempts to suggest damage results from a criminal act.

### **Market conditions**

- Run seller and customer focus groups beforehand to gauge their reaction to the product features.
- Run a smaller scale pilot for a limited period, perhaps restricted by geography or channel and capture the learning before deciding whether to roll out fully.
- Ensure there is a robust plan for achieving sales targets with adequate contingency for possible market effects.
- Put monitoring in place to pick up whether competitors are copying the idea and what their rating movements are.
- Put measures in place to increase certainty of claims treatment, such as:
  - Require claimants to report crimes to the police (to reduce the chance of non-criminal claims being described as criminal).

- Ensure that the criteria for proving that a claim is crime-related are properly defined and clearly communicated to claims staff, brokers and policyholders.
- Put restrictions in underwriting and claims systems to enforce rules and reduce the chance of claims leakage.
- Ensure there is a precise definition of crime-related claims in the policy wording reviewed by underwriting, claims and legal experts.
- Create a robust training plan and test it before roll-out.
- Brief reinsurers on the proposition and give details of expected changes in claims and mix of business.

#### **Portfolio movements**

- Be vigilant against increased fraud or an unexpected rise in certain types of claim by ensuring adequate claims controls are in place.
- Run a portfolio model to predict changes in mix of business and put monitoring of mix of business in place to pick up possible antiselection.
- Plan to review expense allocation after a suitable period to assess whether loadings are suitable.
- Ensure that renewal experience can be split by cohort to identify the policies on old and new excesses.

### **END OF EXAMINERS' REPORT**



# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

18 April 2011 (pm)

### **Subject ST8 — General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all nine questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p>
--

- 1** Explain the difference between the cover given under credit insurance and creditor insurance, giving examples where appropriate. [4]
- 2** You are talking to one of your friends and tell him that you are studying credibility theory. He is a trainee solicitor and is aware of basic insurance concepts but has never heard of credibility theory. He asks you to explain to him how credibility techniques could be used to set premium rates for his professional indemnity cover.
- Outline the points that you would make to him. [4]
- 3** Describe the five modules that typically make up a catastrophe model. [6]
- 4** State the possible regulatory restrictions that may be imposed on the actions of a general insurer. [7]
- 5** (i) List the adjustments that need to be made to a risk premium in order to calculate an office premium. [4]
- A general insurance company underwrites a household property insurance account that has an outwards quota share reinsurance contract.
- The account is expected to run at a loss ratio of 60% gross of reinsurance and 55% net of reinsurance. These loss ratios are calculated after the deduction of all commissions.
- (ii) Suggest why the expected net loss ratio is less than the expected gross loss ratio. [1]
- The quota share reinsurance has an event limit that allows the insurer to recover no more than a fixed amount per event. The reinsurer is proposing to increase this limit.
- (iii) Discuss how this might affect the expected net loss ratio. [5]
- The company also writes product liability insurance. A colleague suggests that the gross premium should be set for the household property account to achieve a higher target loss ratio than the product liability account.
- (iv) Discuss this statement. [7]
- [Total 17]

- 6** A reinsurance company is considering whether to write a property catastrophe reinsurance contract. When the contract exposures are run through a catastrophe model, the outputs in the tables below are obtained. The catastrophe model allows for all the losses that can occur under the contract. The mean loss of 1,090,000 is also an output from the model.

<i>OEP</i>	<i>Loss</i>	<i>AEP</i>	<i>Loss</i>
0.0001	12,639,194	0.0001	18,412,294
0.0002	11,845,886	0.0002	16,664,104
0.001	9,197,946	0.001	13,063,372
0.002	8,170,147	0.002	11,654,574
0.004	7,076,740	0.004	10,230,803
0.005	6,822,562	0.005	9,862,764
0.01	6,137,908	0.01	7,940,776
0.02	5,383,971	0.02	6,604,098
0.04	4,320,107	0.04	5,380,859
0.1	3,073,762	0.1	3,630,884
0.2	1,558,238	0.2	1,852,218
0.5	184,804	0.5	237,743

- (i) Define the terms OEP (occurrence exceedance probability) and AEP (aggregate exceedance probability). [2]

The following definitions are used:

- “gross premium” is the premium charged to the cedant;
- “net premium” is gross premium net of brokerage;
- “underwriting profit” is gross premium less brokerage, other expenses and ultimate claims.

Brokerage is 15% of gross premium and other expenses are 10% of net premium.

- (ii) Calculate the gross premium required to generate a 90% probability of making an underwriting profit in any given underwriting year. [2]

The contract is priced to achieve an expected gross loss ratio of 50%.

- (iii) Calculate, using linear interpolation, the probability that the combined ratio is greater than 100%. [3]

The reinsurance underwriter requests the purchase of some retrocession protection for this contract. Protection is required against all events occurring less frequently than 1 in 150 years.

- (iv) Define the terms retrocessionnaire and retrocedant. [1]

- (v) Estimate, using linear interpolation, the attachment point that the retrocession contract should have, in order to meet the underwriter’s requirements. [2]  
[Total 10]

- 7** A general insurance company writes an annual travel insurance product for students travelling for long periods. The policy pays a fixed sum in the event of loss of luggage, hospital expenses and the cost of flying the student home, where necessary, as a result of an accident or illness.

Analysis of past data shows that claims emerge following a Poisson distribution with a parameter of 0.05. When a claim does occur, the claim cost has the following discrete probability distribution:

<i>Event</i>	<i>Loss of Luggage</i>	<i>Hospital Stay</i>	<i>Flight Home</i>
Fixed Benefit	£250	£750	£5000
Probability	0.80	0.19	0.01

- (i) Calculate the first three moments of the claim cost distribution arising from these policies. [3]
- (ii) Calculate the mean, variance, skewness and coefficient of skewness for the compound distribution. [2]
- (iii) Determine the parameters of the translated gamma distribution that would be used to approximate the compound distribution, giving your answers correct to 5 decimal places. [4]

There are currently 1,000 live policies.

- (iv) Calculate, using a Normal approximation to the compound distribution, the probability that the aggregate claims for these 1,000 policies exceeds £30,000 in a year. [3]
  - (v) State two advantages of using a Normal approximation to an aggregate claim distribution model rather than a recursive model. [1]
- [Total 13]

- 8 A general insurance company is pricing an employers' liability contract for a fishing business involving a large fleet of fishing vessels in the country Eeland. In this country, claims are frequent but their amounts are fixed. The contract will be denominated in the local currency, the Eero (E).

The company is calculating historical exposure for previous policy years using the payroll given in the following table. The 2011 figure is estimated.

<i>Fiscal Year</i>	<i>Fiscal Period</i>	<i>Annualised Payroll (Em)</i>
2007	1 May 2007–30 April 2008	55.0
2008	1 May 2008–30 April 2009	70.0
2009	1 May 2009–31 Dec 2009	71.0
2010	1 Jan 2010–31 Dec 2010	75.0
2011 (est.)	1 Jan 2011–31 Dec 2011	80.0

- (i) Project a payroll figure for the 2012 fiscal year, explaining your reasoning. [1]

The 2011 policy year runs from 1 July 2011 to 30 June 2012. All previous policy years ran from 1 July to 30 June.

- (ii) Estimate the exposure for each of the five policy years 2007-2011 so that it can be used for rating the 2011 policy. Use an assumed average rate of earnings inflation of 5% and state any further assumptions that you make. [7]

The following table contains historical aggregate claims under the policy, trended to current levels and projected to ultimate.

<i>Policy Year</i>	<i>Trended Ultimate Claims (Em)</i>
2007	2.30
2008	3.75
2009	3.55
2010	2.80

The underwriters think that the high claims in policy years 2008 and 2009 are due to the economic climate and they estimate the effect of this to be a 30% increase in total claim amounts in these years. They do not believe that there should be an increase in any other year, including 2011.

- (iii) Estimate the expected losses for the 2011 policy year by removing the effects of the economic climate, stating any assumptions that you make. [4]
- (iv) Discuss the issues involved in selecting the policy years to use as a basis for rating the 2011 policy. [3]

The underwriters suggest building a model to rate individual fishing vessels.

- (v) Suggest rating factors that may be used in this model. [3]
- [Total 18]

- 9** A large general insurance company is considering whether to start writing insurance for wind turbines. Wind turbines use wind energy to produce electricity, and the technological development of these turbines has been advancing rapidly in recent years. For the purposes of insurance, wind farms are treated as power plants. The insurance would cover the company that operates the turbines, rather than the manufacturer.

As the company has not written this type of insurance before, it will initially need to rely on external information.

- (i) List the perils that the insurance company might be asked to cover. [4]
- (ii) Suggest sources of external information that the company could use to help to price this business. [2]
- (iii) Discuss the potential problems with using external data for calculating premium rates for this class of business. [4]
- (iv) Discuss the information that the company would seek from a wind turbine operator in order to price a policy effectively. [11]

[Total 21]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

April 2011 examinations

**Subject ST8 — General Insurance: Pricing  
Specialist Technical**

- 1** Credit insurance covers a creditor against the risk that debtors will not pay their obligations.  
e.g. trade credit, mortgage indemnity guarantee.

Creditor insurance provides cover to individuals who are subject to obligations to repay credit advances or debt.

e.g. to cover personal loans, mortgage loans or credit card debts.

Creditor cover is usually against disability or unemployment as these perils may prevent the insured from receiving an income ...

... while credit insurance covers non-payment for any reason.

Creditor cover will pay the regular loan payments until the borrower is recovered / working / loan is paid off or a policy limit is reached...

... whereas credit insurance is likely to pay a one-off lump sum for the amount owed upon default of the debtor.

*A common error in this part was interchanging the definitions of the two types of insurance.*

- 2** We would usually use the past history of claims from an insured or a group of insureds (e.g. a firm of solicitors) in order to estimate the future costs of providing insurance.

But many events are random so we do not know what the true cost of claims will be in the future.

The claims from the last few years may not always be a good estimate of the future, especially if there haven't been many claims, or their final amounts are uncertain.

So we might get a better estimate by combining this past data with some other information about professional indemnity risks.

This other information is often obtained from a larger pool of claims.

The more data we have on the individual risk, and the more stable the experience, the more credible it is.

For example, suppose that recent experience indicates that an individual solicitor should be charged a rate of £180 for £100,000 of professional indemnity insurance cover but the normal rate for other risks is £165 (this is the "other information"). The new rate could be £180 or £165 or something in between, and credibility theory helps us to decide.

There are different mathematical models that can be used to come up with the weightings to use. (*NB – it is not appropriate to go into these in this answer*)

The other elements of premium (expenses, profit etc) need to be added on to the cost of claims to determine the final premium.



*Most candidates started their answers well and explained the basic points, but many went on to include detailed theory and formulae, for which no credit was available. Looking at the marks available for the question should have indicated that a great level of detail was not required. Very few candidates gave a good example or mentioned other elements of premium besides claims cost.*

### 3

- Event module

A database of stochastic events (the event set) with each event defined by its physical parameters, location and annual probability/frequency of occurrence.

- Hazard module

This module determines the hazard of each event at each location. The hazard is the consequence of the event that causes damage.

For example in the case of a hurricane wind speed is the primary cause, for an earthquake it is ground shaking (or other suitable example).

- Inventory (or exposure) module

A detailed exposure database of the insured systems and structures.

This will include details such as location, age, occupancy or construction.

- Vulnerability module

Vulnerability can be defined as the degree of loss to a particular system or structure resulting from exposure to a given hazard.

- Financial Analysis module

Uses a database of policy conditions to translate the total ground-up loss into an insured loss.

The inventory and financial analysis modules rely primarily on input data that is specific to the user of the models *(must say both modules to score fully)*

The other three modules are based on scientific assessment (seismology, meteorology and engineering). *(must say "others" or name modules to score fully)*

*Common errors in this bookwork question were:*

- *putting limits, deductibles etc. in the vulnerability module, rather than the financial analysis module*
- *stating the wrong name for the "Financial Analysis" module*
- *failing to pick up the final two points*

- 4** The following regulatory restrictions on the actions of a general insurer may be encountered in one or more countries of the world:
- Restrictions on the territory or type of business a general insurer can write or the classes for which the insurer is authorised.
  - Limits or controls (including requirement to file rates) on the premium rates that can be charged.
  - Restrictions on the information that may be used in underwriting and premium rating.
  - A requirement to deposit assets to back claims reserves.
  - A requirement that the general insurer maintains a minimum level of solvency.
  - Restrictions on the types of assets or the amount of a particular asset that a general insurer can take into account for the purposes of demonstrating solvency.
  - A requirement to use prescribed bases for calculating and/or liabilities (including technical reserves) when demonstrating solvency.
  - A requirement to take account of uncertainties and risks in the business when calculating the solvency requirement.
  - Restrictions on individuals holding key roles in companies.
  - Licensing of agents to sell insurance and requirements on the methods of sale and disclosure of commission / broking terms.
  - A requirement to pay levies to consumer protection bodies.
  - Legislation to protect policyholders if a general insurer fails.
  - Limitation of ownership e.g. only own 49% of Indian company.
  - Monopoly and merger restrictions.
  - Requirement to have an office in a location if underwriting there.
  - Restrictions as to whether claims equalisation reserves are needed.
  - Compulsory covers e.g. requirement to offer terrorism cover in some countries or to offer flood (or other) cover to high-risk policyholders.
  - Prescribed policy conditions or minimum level of cover allowed on specific classes.
  - Requirement to produce financial reports or accounts.
  - Requirements on level, type or quality of reinsurance protection.
  - Requirement to uphold customer treatment standards.

*Most candidates scored well on this bookwork question, although few gained full marks. Many ignored the “state” command word and gave unnecessarily long descriptions.*

- 5** (i) Adjustments are:
- A loading for reinsurance.
  - Loadings for internal expenses (claims handling/admin/overheads).
  - Acquisition expenses, such as commissions and aggregator fees.
  - A capital charge to reflect cost/availability of capital.
  - Allowance for profit.
  - Contingency loading.
  - Investment income.

- Explicit discounts, such as NCD or cashback.
- Tax...
- ...e.g., premium or purchase tax; tax on profits (or other valid example).
- Levies...
- ...e.g., policyholder protection; fire brigade (or other valid example).
- Adjustments or cross-subsidies to allow for competition and market forces.
- Adjustments or cross-subsidies to allow for expected policy lifetime (new/renewal).
- Adjustment to reflect strategy or relationships (eg market share, broker relationships).
- Practical constraints of the rating structure or computer system.
- Regulatory constraint (e.g., maximum or minimum rates).

*Most candidates scored close to full marks on this part.*

(ii)

Commissions paid to insurer from reinsurer are greater than those paid out by the insurer to brokers...  
...as a result of:

- Overrides/commissions to cover insurer's expenses.
- Profit commissions.
- ...especially as the account seems to be quite profitable.

*Some candidates appeared to forget that this is a quota share contract. Many failed to demonstrate understanding of how overrides and profit commissions operate.*

(iii) Points:

- If commissions remain the same:
  - We can expect to recover more on large claim events.
  - Lowering the net loss ratios.
- In reality the commissions will change to reflect this i.e. reinsurance commission will decrease.
- A higher event limit decreases our losses from large events i.e. lowers the volatility of losses we expect.
- Lower volatility lowers the capital charge on the account.
- Hence decreases the office premium.
- Hence can be written at a higher loss ratio.
- Assuming the reinsurance commission change doesn't swamp it.
- Expected recoveries from a particular reinsurer are greater.
- Credit (reinsurer default) risk may increase.
- This is especially relevant as credit ratings may decrease after a large event.

- Hence we will increase the office premium, lowering the expected net loss ratio.

*This part was generally not answered well. Frequent errors were:*

- *stating that the reinsurance premium would go up, even though this is a quota share contract*
- *mistaking the limit for an excess, even though its operation was described in the question*
- *omitting credit risk and claims volatility*

(iv) Points For and Against and Neutral

**For**

- The market for household might be more competitive than for product liability.
- Pricing product liability business is more uncertain than household.
- and will hence need a higher capital charge...
- ...because of:
  - Long tail – difficult to accurately reserve old claims.
  - Inflation more uncertain.
  - Latent claims.
  - Less data.
  - Other suggestions.

**Against**

- Property may be susceptible to natural catastrophes.
- This will require high capital charges.
- Investment returns should be better on product liability business.

**Neutral**

- Must also consider:
  - Reinsurance charges on different business.
  - Different regulatory capital requirements.
  - Different economic capital requirements due to mix of business in the company.
  - Expectations of shareholders, impacting required return on investment.
  - Position in insurance cycle could be different.
  - Expenses/commission.
  - The insurer's strategy for the two classes.

*Answers to this part were very mixed. The stronger candidates broke down their answers into sections, as above. Some candidates mistook target loss ratios for premium levels.*

- 6 (i) OEP – the probability that the largest individual event loss in a year exceeds a particular threshold.

AEP – the probability that the aggregate losses from all loss events in a year exceeds a particular threshold.

*Precise definitions were required to get full marks. Many candidates wrote "a single" instead of "the largest" for the definition of OEP.*

(ii)

Loss (1 in 10)	3,630,884	From AEP table
Expense adjustment	0.9	1–10%
Brokerage adjustment	0.85	1–15%
GP	4,746,254	Loss / (0.85 × 0.9)

*The most common mistakes here were using figures from the OEP table instead of AEP, or multiplying by 1.15 instead of dividing by 0.85. Some candidates, who were in doubt about whether to use the OEP or AEP table, gave two different answers. In this situation, even when one answer was correct, marks could not be awarded for it.*

(iii)

Expected Loss	1,090,000	
GP	2,180,000	loss/.5
NP	1,853,000	GP × (1 – 15%)
Expenses	185,300	NP × 10%

NP – Expenses 1,667,700

Required loss 1,667,700

Interpolated	$x_i$	$f(x_i)$	$wt_i$
	1,852,218	0.2	89%
	237,743	0.5	11%
	$X$	1,667,700	
	$f(x)$	<b>0.23</b>	

*In general, candidates who answered part (ii) correctly went on to make a good attempt at part (iii).*

- (iv) The ceding reinsurer in a retrocession contract is called the **retrocedant**.  
The assuming reinsurer is called the **retrocessionnaire**

*Bookwork and answered very well by almost all candidates.*

(v)

Probability	0.0067		
Interpolated	$x_I$	$f(x_i)$	$wt_i$
	0.0050	6,822,562	67%
	0.0100	6,137,908	33%
	$X$	0.0067	
	$f(x)$	<b>6,594,344</b>	

*The most common mistake in this part was to use figures from the AEP table instead of OEP. Again, where two different answers were given, neither could be credited.*

**7** (i)  $E(X) = (250 * 0.8) + (750 * 0.19) + (5,000 * 0.01) = 392.5$

$$E(X^2) = (250^2 * 0.8) + (750^2 * 0.19) + (5,000^2 * 0.01) = 406,875$$

$$E(X^3) = (250^3 * 0.8) + (750^3 * 0.19) + (5,000^3 * 0.01) = 1,342,656,250$$

*This part was generally well-answered.*

(ii)  $E(S) = \lambda E(X) = 0.05 * 392.5 = 19.625$

$$\text{Var}(S) = \lambda E(X^2) = 0.05 * 406,875 = 20,343.75$$

$$\text{Skew}(S) = \lambda E(X^3) = 0.05 * 1,342,656,250 = 67,132,812.5$$

$$\text{Coeff}(S) = \frac{\text{Skew}(S)}{\text{Var}(S)^{1.5}} = \frac{67,132,812.5}{(20,343.75)^{1.5}} = \frac{67,132,812.5}{2,901,660} = 23.136$$

*Many candidates did not calculate the coefficient of skewness in this part.*

(iii) Let  $Y + k$  be a gamma random variable with the same moments as  $S$ .

Equating parameters:

$$E(S) = (\alpha / \delta) + k = 19.625$$

$$\text{Var}(S) = \alpha / \delta^2 = 20,343.75$$

$$\text{Coeff}(S) = 2 / \sqrt{\alpha} = 23.136$$

OR:

$$\text{Skew}(S) = 2\alpha / \delta^3 = 67,132,812.5$$

Solve simultaneous equations to give:

Sensible workings shown

$$\alpha = 0.00747$$

$$\delta = 0.00061$$

$$k = 7.29517$$

*Answers could be very sensitive to rounding precision. Full credit was given if correct to 5dp for alpha and delta and 2dp for k. This should allow for using 7dp in underlying calculations.*

*Candidates normally used their answers from part (ii) correctly, but some failed to provide sufficient workings that would have generated partial credit even where final answers were wrong.*

- (iv) For 1,000 policies,  $E(S) = 1,000 * 19.625 = 19,625$   
And  $\text{Var}(S) = 1,000 * 20,343.75 = 20,343,750$   
(because  $\text{Var}(S) = E(N)\text{Var}(X) + \text{Var}(N)[E(X)]^2$  and  
 $E(N) = \text{Var}(N) = 1,000 * 0.05$  so  $\text{Var}(S) = 50 * E(X^2) = 20,343,750$ )

$$\begin{aligned}\Pr(S > 30,000) &= \Pr\left[N(0,1) > \frac{30,000 - 19,625}{\sqrt{20,343,750}}\right] \\ &= 1 - \Phi(2.3) \\ &= 1 - 0.98928 \\ &= 0.01072\end{aligned}$$

*A common mistake was to use a factor of  $1000^2$  instead of 1000 when calculating  $\text{Var}(S)$ .*

- (v) It can require a significant amount of computer time to calculate values for  $G(x)$

The recursion formula cannot be used unless the distributions of both  $N$  and  $X_i$  are known (or can be estimated fairly precisely).

*Most candidates wrote the first point but very few went on to get the second.*

## 8

A general problem with this question was inability to interpolate correctly.

(i)

Give credit for any reasonable estimate with adequate explanation  
e.g. Growth in the last 2 years is 5m => select 85m.

Going forward we use E85m

Most candidates gave a sensible estimate with reasoning.

(ii)

Two methods are shown, each using a different order of trending and interpolating

### Method 1 – Trend then interpolate

Fiscal Year	Payroll (Em)	Mid point		Years Trend	Trend Factor
		Fiscal Year	Policy Year		
2007	55.0	01/11/2007	01/01/2012	4.17	1.23
2008	70.0	01/11/2008	01/01/2012	3.17	1.17
2009	71.0	01/09/2009	01/01/2012	2.33	1.12
2010	75.0	01/07/2010	01/01/2012	1.50	1.08
2011	80.0	01/07/2011	01/01/2012	0.50	1.02
2012 (proj)	85.0	01/07/2012	01/01/2012	(0.50)	0.98

Fiscal Year	Trended Payroll
2007	67.4
2008	81.7
2009	79.6
2010	80.7
2011	82.0
2012	83.0

$55 \times 1.226$   
 $70 \times 1.167$   
 $71 \times 1.121$   
 $75 \times 1.076$   
 $80 \times 1.025$   
 $85 \times 0.976$

Policy Year	Mid Point	Tr Payroll
2007	01/01/2008	69.79
2008	01/01/2009	81.27
2009	01/01/2010	80.02
2010	01/01/2011	81.35
2011	01/01/2012	82.47

$= (2 \times 81.7 + 10 \times 67.4) / 12$   
 $= (2 \times 79.6 + 8 \times 81.7) / 10$   
 $= (4 \times 80.7 + 6 \times 79.6) / 10$   
 $= (6 \times 82.0 + 6 \times 80.7) / 12$   
 $= (6 \times 83.0 + 6 \times 82.0) / 12$



## Method 2 – Interpolate then trend

<i>Fiscal Year</i>	<i>Payroll (Em)</i>
2007	55.0
2008	70.0
2009	71.0
2010	75.0
2011	80.0
2012	85.0

Linearly interpolate onto historical policy years. Always 1 July

<i>Policy Year</i>	<i>Mid Point</i>	<i>Tr Payroll</i>	
2007	01/01/2008	57.50	$= (2 \times 70 + 10 \times 55) / 12$
2008	01/01/2009	70.20	$= (2 \times 71 + 8 \times 70) / 10$
2009	01/01/2010	72.60	$= (4 \times 75 + 6 \times 71) / 10$
2010	01/01/2011	77.50	$= (6 \times 80 + 6 \times 75) / 12$
2011	01/01/2012	82.50	$= (6 \times 85 + 6 \times 80) / 12$

<i>Policy Year</i>	<i>Payroll (Em)</i>	<i>Years Trend</i>	<i>Trend Factor</i>	<i>Trended Payroll (Em)</i>	
2007	57.5	4	1.22	69.9	$57.5 \times 1.216$
2008	70.2	3	1.16	81.3	$70.2 \times 1.518$
2009	72.6	2	1.10	80.0	$72.6 \times 1.103$
2010	77.5	1	1.05	81.4	$77.5 \times 1.05$
2011	82.5	0	1.00	82.5	$82.5 \times 1$

Assumptions:

- Linear interpolation is appropriate when converting fiscal year exposure to policy year exposure (*accept “payroll is uniform within each fiscal year”*).
- The mid-point of the policy year is suitable for approximating the earnings growth.
- The same weight is given to shorter fiscal periods as longer ones in the calculation.

Going forward we use the results from M1.

*Most candidates chose to interpolate then trend, but many struggled with policy years 2007 and 2008. Credit was given for alternative assumptions where these were consistent with the calculation method. However, no credit was given for “uniform incidence of risk” or “policies written evenly over the year” (since there is only one policy).*

(iii)

<i>Policy Year</i>	<i>Claims /Exp (m)</i>	<i>Economic Load</i>	<i>Economic Adjustment</i>	<i>Adjusted Claims/Exp (m)</i>
2007	32,956		1.00	32,956
2008	46,142	30%	0.77	35,494
2009	44,362	30%	0.77	34,125
2010	34,419		1.00	34,419
2011				

Estimate 2011 claims/exp figure (eg average 07-09 = 34,191)

Use exposure and claims (eg  $82.47 \times 34,191 = 2,819,732$ )

Assumptions in selection and calculation:

- Economic climate only affects claims per unit exposure, not exposure itself
- All years are representative and can be used
- Assume no change to Ts&Cs
- Assume payroll is adequate risk measure

*Very few candidates followed the exact approach suggested above, but equivalent valid approaches were given full credit. The usual approach was to adjust the trended ultimate claims from part (ii) for 2008-9, divide each by the appropriate payroll, take an average and multiply by the 2011 payroll.*

(iv) Discussion of which years to select:

- Older years are less relevant as they come from a differing claims environment
- e.g. propensity to claims or exposure less predictive or different working practices
- Some of the policy years may be less relevant because of changes in cover
- Older years are more sensitive to errors in the trend rate for claims or exposure
- Newer years are less developed and hence more uncertain
- This is especially true in liability business
- However this may not be the case here due to the fixed awards
- Using more years reduces the effect of random fluctuations in any one year (gives more stability)
- 2008-9 may be less reliable because they have been adjusted

*Most candidates made some valid points, but few scored full marks. Some students did not attempt this part of the question, whilst others misread it and discussed the issues of using policy year as opposed to fiscal year.*

(v) Possibilities are:

- Average age of crew
- Experience of crew
- Size of crew
- Wages of crew
- Days spent at sea
- Type of vessel

- Condition/age of vessel
- Type of fishing
- Location
- Safety precautions on board
- Safety training of staff
- Overall fleet size (may affect risk management capabilities)
- Claims experience
- Additional coverages e.g. GL
- Tools handled
- Size of vessel
- Type of propulsion/fuel
- Period of cover

*Some candidates forgot that this question related only to employers' liability and listed factors that would be used for property damage classes.*

**9** (i)

- Fire
- Explosion
- Hail / tornado
- Windstorm / hurricane
- Flood
- Extremes of temperature
- Subsidence/heave
- Lightning
- Breakdown/failure of machinery
- Liability for damage to property of a third party eg damage to a road or the power grid
- Liability for death or bodily injury sustained by a third party
- Employers' liability for people employed at the site
- Earthquake
- Volcano
- Nuclear, chemical, biological
- Theft (eg copper wiring)
- Malicious damage / vandalism
- Impact
- Wave/tsunami damage
- Accidental damage
- Damage to parts in transit
- Loss of profits/consequential loss
- Terrorism/war
- Power surge from grid
- Environmental damage/pollution
- Exploration and construction risks

*Most candidates generated a variety of perils.*

(ii)

- Reinsurer or broker data
- Competitor rates for similar power plants
- Aggregate market statistics (if these exist)
- Industry/scientific studies e.g. by environmental groups, meteorology
- Academia, e.g. engineering studies
- Publicly available data curves
- Catastrophe model vendors

*Most candidates identified a good range of data sources.*

(iii) External data may be:

- sparse,
- not developed, as the cover is new and fast-evolving
- out of date
- of poor quality
- not detailed enough (especially for pricing)
- not representative of the type of business you want to sell or of the insureds you intend to sell to
- expensive

There will be heterogeneity

...due to:

- data coming from wind turbines in different countries, each with different exposure to storms, earthquakes etc.
- differing levels of cover  
e.g. loss of profits included/excluded (or similar example)  
or different limits, deductibles, excesses
- the nature of the data stored by different insurers being different e.g. claims information may be paid or paid + outstanding
- inconsistent coding of data
- if claim figures include outstanding amounts, different insurers are likely to have different reserving philosophies
- different insurers having different procedures e.g. claims handling and settlement, underwriting, making it difficult to compare claims amounts
- different loadings for expenses and profit in different insurer's premiums

*This part was generally well-answered, with most candidates making a variety of points.*

(iv) Cover details:

- term required e.g. 1 year, 5 years
- deductible or excess required
- limits of cover required
- types of cover
- exclusions

Rating factors:

- territory in which the wind turbines are located
  - as this affects the exposure to weather-related perils like storm or lightning and to earthquakes
  - also affects legal environment for liability claims ...
  - ... and exchange rates and local inflation rates will affect the cost of repair
  - may affect possible compensation claims eg proximity to a highly populated area
- whether located on land or in the sea
  - this affects theft or wave damage (or other suitable example)
- size of plant/number of turbines covered
- plans for upgrading turbines or increasing the numbers in the future
- value of plant (sum insured/ EML)
- power/size of the turbines
  - more power may mean more potential issues
- ease of access for repairs
  - e.g. is it necessary to build a road big enough to take a crane before repairs can be carried out
- manufacturer of the turbines
  - may affect quality, may have guarantees that kick in before the insurance
- model of turbine
- age of the turbines
  - this will also reflect the level of technology (which is changing fast)
- safety features/procedures within the turbines
  - e.g. lightning conductors, circuit breakers
- quality of management of turbine operator
  - levels of monitoring, frequency and quality of maintenance and servicing procedures, staff training
- security of the site
  - affects theft & vandalism & liability
- Turnover/profit
  - for business interruption cover
- Size of workforce/payroll
  - relevant to employers' liability
- Last year's premium

History of losses:

- numbers of losses (whether claimed for or not)
  - may give an idea of the likelihood of future losses, together with any actions taken to prevent similar claim events happening in the future
- cause/peril/type of losses for each one
- exposure details to match claims history
- rating factor details to match past claims
  - since turbines may have been upgraded, meaning that past risks are no longer likely

- dates
- claim status
- amounts & estimates
- currency

*Most candidates made a variety of valid points, but often tended to generalise by stating “rating factors” or “claims data” without enough specific details. Very few mentioned that historical exposure and claims data should match (ie correspond).*

## **END OF EXAMINERS' REPORT**

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

26 September 2011 (pm)

### **Subject ST8 — General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all nine questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p>
--

- 1 (i) State the reasons why a general insurance company would use reinsurance. [4]

A general insurance company underwrites an individual commercial property risk with an EML of £21.6m. The risk is reinsured under a surplus treaty with a retention of £3m. The company has recently settled a claim for £24.5m.

- (ii) Calculate the amount that can be recovered under the surplus reinsurance treaty in respect of this claim. [2]

[Total 6]

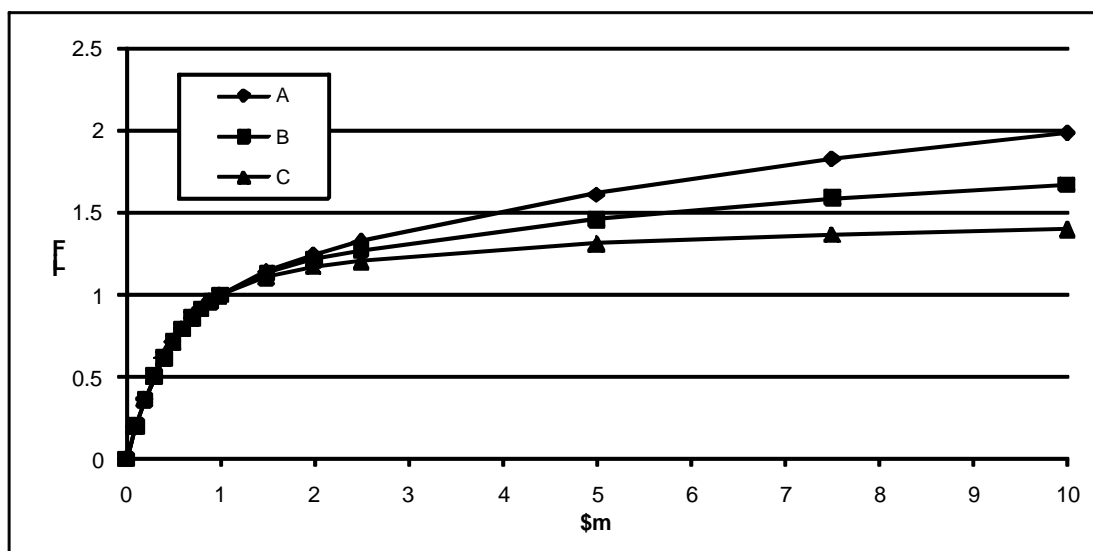
- 2 A general insurance company is reviewing the ILF curves used in its public liability insurance book. A computer model is used to fit the ILF curves to historical claims. The user of the model must input ground up claim records, each of which has the following data:

- Date of loss
- Ground up claim expense, after inflation to current values
- Ground up indemnity amount, after inflation to current values

As part of tort reform, legislation has recently been passed to limit indemnity payments to \$1m.

- (i) Describe how the original claims data should be adjusted before they can be used in the ILF computer model. [2]

Consider the three ILF curves shown below. Curve B arises from the claims before tort reform.



- (ii) Explain which of A and C would be more appropriate after the reform. [2]

[Total 4]



**3** A large general insurance company writes product liability business.

The pricing manager would like to know what the true rate change has been between the 2009 and 2010 renewals for a particular product liability policy. The policy has been subject to some significant changes over the year and the pricing manager has asked an underwriter for his view on the rate change.

- (i) State the advantages and disadvantages of relying on this method of determining the rate change. [3]

The pricing manager has asked for a calculation of the rate change for the policy using the premium and cover details given below.

<i>Policy Year</i>	<i>Policy Excess (£)</i>	<i>Policy Limit (£)</i>	<i>Turnover (£)</i>	<i>Line</i>	<i>Coinsurance Share of Premium (£)</i>
2009	100,000	900,000	1,000,000	20%	4,900
2010	500,000	1,000,000	1,500,000	23%	2,700

The policy limit restricts the maximum claim amount to £900,000 in 2009 and £1,000,000 in 2010. There have been no other changes to the risk or cover of the policy from 2009 to 2010 and there are no size-related or experience-related discounts in the price.

The following table of increased limit factors has been provided for use with this policy.

<i>Limit (£)</i>	<i>ILF</i>
100,000	1.000
500,000	2.300
1,000,000	2.750
1,500,000	2.900
2,000,000	3.000

- (ii) Calculate the change in premium rate between 2009 and 2010, ignoring the effects of inflation. [5]  
[Total 8]

**4** A general insurance company is building an employers' liability pricing model.

Discuss the issues arising in choosing the number of years' past data to use. [8]

**5** A Bermudan catastrophe reinsurer specialises in US household exposures.

- (i) List possible perils that could cause large losses to the reinsurer. [2]

The reinsurer wishes to price a hurricane-only policy. The cedant has provided a list of current exposures on the policy, which the reinsurer has put into a catastrophe model. An extract of the output is given below.

<i>Event ID</i> (1)	<i>Loss to policy</i> (2)	<i>Frequency</i> (3)	<i>Expected Loss</i> (4) = (2) × (3)
6531	62,500,607	0.001	62,501
6532	50,000,486	0.002	100,001
6533	12,000,117	0.001	12,000

The total expected annual loss to the policy is calculated by summing column (4).

- (ii) Give reasons, other than the underlying volatility of claims experience, why the total expected annual loss from the catastrophe model may differ from the actual long-term average. [7]

The cedant proposes to issue an Industry Loss Warranty (ILW) as an alternative reinsurance cover, and wishes to use the above catastrophe model output to calculate the expected claims to the proposed ILW.

- (iii) State the other items of data about each event that are required for this purpose. [1]

The proposed ILW has unlimited free reinstatements.

- (iv) Describe how you would model the expected claims to the ILW, with reference to the catastrophe model output in part (ii). [2]

[Total 12]

- 6 A general insurance company is pricing a professional indemnity annual policy that renews on 1 October 2011. The insured is an actuarial consultancy.

- (i) Give two examples of perils covered by this policy. [1]
- (ii) List possible rating factors for this policy. [2]

The policy is written on a claims-made basis.

- (iii) Compare the cover given on a claims-made basis with that of a losses-occurring basis for this type of policy. [2]

Historical claims and exposure data are to be used to estimate a premium for the 2011 policy.

- (iv) Suggest two exposure measures that do not need to be adjusted to allow for inflation. [1]

The table below shows the historical exposure on a losses-occurring basis by policy year, inflated to the midpoint of the 2011 policy year.

<i>Policy Year beginning 1 October</i>	<i>Inflated Turnover (£m)</i>
2007	82.4
2008	85.7
2009	86.9
2010	90.0
2011 (estimated)	95.0

In order to move to a claims-made basis, the delay table below is used. It implies that, of the claims made in any policy year, 25% of the ultimate claims amount comes from events occurring in that year, 50% from the year before and the remaining 25% from the year before that.

<i>Delay</i>	<i>% of Claims</i>
-2	25%
-1	50%
Current	25%

Exposure for rating on a claims-made basis is to be used.

- (v) Convert the exposure onto a claims-made basis for policy years 2009, 2010 and 2011. [3]

It is now proposed that for policy years 2009, 2010 and 2011, the policy will only cover claims occurring on or after 1 October 2009.

- (vi) Recalculate the claims-made exposure for each of these policy years, stating any assumptions that you make. [3]

[Total 12]

**7** A reinsurer is pricing some 2011 quota share contracts.

- (i) Describe the characteristics of quota share reinsurance. [3]

The experience of two contracts is as follows:

<i>Year of Account</i>	<i>Ultimate Loss Ratios</i>	
	<i>Insurer A</i>	<i>Insurer B</i>
2008	59%	51%
2009	51%	55%
2010	43%	40%

The loss ratios are ultimate losses / premium net of brokerage.

The following rate changes have been applied for Insurer A:

2008 to 2009	–2%
2009 to 2010	4%
2010 to 2011	5%

- (ii) Amend Insurer A's loss ratios for a 2011 rating environment, ignoring the effects of claims inflation. [3]

The company is considering a further contract, for Insurer C. Historical ultimate loss ratios to the contract are shown below. The loss ratios have been adjusted onto 2011 pricing, brokerage and claims levels.

<i>Year of Account</i>	<i>Ultimate Loss Ratio</i>
2000	103%
2001	92%
2002	72%
2003	85%
2004	89%
2005	83%
2006	81%
2007	76%
2008	81%
2009	99%
2010	84%
<i>Mean</i>	86%
<i>Standard deviation</i>	9%

Insurer C wants to include a profit commission on the contract for the first time. Under the profit commission the reinsurer will pay 20% of the profit in the year of account to Insurer C, where the profit is defined by the formula

$$\text{profit} = \text{premium net of brokerage} - \text{expenses} - \text{ultimate losses}$$

Expenses are defined as 30% of premium.

The above loss ratios have a long term average of 86%, which the reinsurer considers to be a reasonable estimate of the 2011 loss ratio before profit commission.

A colleague suggests basing the profit commission load for 2011 on the profit commissions that would be paid historically, based on the above formula and tabulated loss ratios.

(iii) Comment on this suggestion. [3]

Another colleague suggests using a probability distribution to estimate the ultimate 2011 loss ratio. She suggests fitting a Normal distribution, with mean 86% and standard deviation 9%, to the loss ratios given in part (iii).

(iv) Comment on these suggestions. [4]

(v) Calculate the probability of a profit commission being paid under the Normal distribution given in part (iv). [3]

The underwriter points out that the percentage ceded under the contract has doubled from 25% in 2000-2003 to 50% in later years.

(vi) Explain whether this will affect your analysis. [1]

[Total 17]

- 8 A large general insurance company needs to calculate the expected loss costs for a 2011 marine insurance policy, using a frequency-severity model. The insured is a large shipping company.

The following information is available:

- the company has 200 ships and this number has been constant for many years;
- the policy deductible is £100,000;
- the policy is on a losses-occurring basis.

The table below lists every claim reported to date against its policy year of occurrence. The amount of each claim is the current ground up (paid plus outstanding) claim amount.

<i>Policy Year</i>	<i>GU Claims (£)</i>					
2004	7,000	14,000	35,000	25,000	-	-
2005	71,000	90,000	34,000	-	-	-
2006	82,000	55,000	185,000	52,000	-	-
2007	103,000	24,000	4,000	148,000	222,000	-
2008	17,000	196,000	311,000	6,000	579,000	-
2009	408,000	100,000	61,000	41,000	689,000	390,000
2010	74,000	128,000	231,000	219,000	64,000	53,000

- (i) Calculate, for each policy year, the number of claims that exceed the deductible at 2011 price levels. Assume a claims inflation rate of 5% p.a. [3]

The development factors for the number of claims reported, in excess of the deductible, are given in the table below.

<i>Policy Year</i>	<i>Number of currently reported claims (in excess of the deductible) as a percentage of ultimate number</i>
2006 & prior	100%
2007	95%
2008	90%
2009	80%
2010	55%

- (ii) Calculate the ultimate number of claims that exceed the deductible for each policy year. [2]
- (iii) Estimate the expected ultimate number of claims for the 2011 policy year, explaining the rationale for your estimate. [2]

It transpires that the information given on the number of ships was incorrect. In fact, the number of ships has been increasing dramatically over the last 10 years.

- (iv) Outline, without doing any calculations, how this might change the analysis in parts (ii) and (iii) above. [2]

The development factors in part (ii) above were specifically developed for similar shipping companies.

- (v) Explain why the factors might not be appropriate. [2]

- (vi) Suggest two distributions that could be used to model the frequency. [1]

A severity distribution is to be fitted to the trended claims.

- (vii) State a further adjustment that should be made. [1]

The completed model will be used to price a policy with an aggregate limit of £10m. The underwriter then reveals that the insured has just acquired a company with 50 ships, which requires coverage as well. A colleague suggests that the price should be increased by 25%.

- (viii) Discuss the appropriateness of this approach. [6]

[Total 19]

**9** A pricing analyst is building a generalised linear model (GLM) to predict the theft claim frequency for a book of household contents policies.

- (i) Write down the structure of a GLM, defining all the terms in the formula. [3]
- (ii) State what is meant by the terms “categorical factor” and “non-categorical factor” in the context of a GLM. [1]
- (iii) Explain how the scaled deviance and Akaike Information Criterion (AIC) statistics can be used to assist with model selection. [4]

The analyst fits an initial model, Model 0, that has a known scale factor and contains several possible rating factors. He then tries two further models, both of which are identical to Model 0 but with one rating factor removed.

Model 1A excludes an “occupied during the day” indicator, which is a two-level factor in Model 0. Model 1B instead excludes “property type”, which is a seven-level factor in Model 0.

The following results are obtained from the analysis.

<i>Model</i>	<i>Scaled Deviance</i>	<i>AIC</i>
0	7003.7	8236
1A	7004.8	8235
1B	7015.0	8241

- (iv) Compare the three models by
    - (a) analysing the significance, at the 5% level, of the rating factors used, and
    - (b) commenting on the results. [6]
- [Total 14]

**END OF PAPER**



# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

September 2011 examinations

### **Subject ST8 — General Insurance: Pricing Specialist Technical**

#### **Purpose of Examiners' Reports**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

T J Birse  
Chairman of the Board of Examiners

December 2011

## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

## **Comments on the September 2011 paper**

The general performance was very similar to April 2011. Well-prepared candidates scored strongly and displayed a good understanding of the subject across the whole paper. There was no evidence of time pressure amongst the better-scoring candidates.

There was a good spread of marks amongst candidates on most questions, but Q4 and Q5 in particular produced relatively low scores. Apart from those, Q3(ii), Q7(iii)-(iv), Q8(v-viii) and Q9(iv) appeared to be the most difficult and tended to discriminate the better candidates.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to concentrate their revision in these areas.

- 1 (i)
- To limit exposure to risk or to spread risk  
*(no credit for simply saying it increases diversification)*
  - E.g., single risks, aggregations of single risks, accumulations, multi-class losses
  - To avoid single large losses e.g. liability claims
  - Reinsurance can increase the opportunity for an insurer to make a profit and plan its business more accurately  
*(no credit for simply saying it increases profits)*
  - To smooth results
  - To improve solvency margins or reduce the required solvency margin
  - To increase an insurer's capacity to accept risk
  - To gain expertise when developing new markets / products
  - To participate in reciprocal arrangements
  - To gain financial assistance
  - e.g. against new business strain
  - For legislative reasons
  - e.g. a compulsory terror pool
  - Could offer tax advantages

*This bookwork part was generally well-answered.*

- (ii) EML = £21.6m  
R = £3m  
So the number of lines ceded =  $(21.6 / 3) - 1 = 6.2$  lines

Therefore all claims will be split in the proportion 6.2 : 1

Claim is £24.5m (it doesn't matter that this is more than the EML)  
...and is also split in the proportion 6.2 : 1

Reinsurer pays  $(6.2 / 7.2) * 24.5m = £21.097m$

*Some candidates did not realise that the claim would be split in the treaty proportions even though it is above the EML. A few candidates appeared not to understand the operation of a surplus treaty properly.*

- 2 (i) Inflate the claims to current day values  
Develop to ultimate (add IBNER)  
Use different trend rates for expenses and indemnity  
Limit inflated, developed indemnity to \$1m  
*(must be clear that capping applies after inflation & development)*  
Consider whether expenses require adjustment as a result of the new indemnity limit and adjust if so.

*Very few candidates mentioned using different adjustments for expenses and indemnity elements. A common error was to state that indemnity amounts should be limited before claim amounts were inflated.*

- (ii) Many claims over \$1m will reduce  
 Not all, though, as there will always be expenses  
 Claims with an indemnity amount under \$1m will remain the same  
 So there will be a flattening of the curve over \$1m  
 The answer is C

*Most candidates recognised that the correct curve was C but few were able to explain clearly why.*

- 3** (i) Main advantage – they can allow for the “soft” factors that would otherwise be unquantifiable.

e.g. subtle changes in terms and conditions, risk management changes, or other sensible non-quantifiable factor

Quicker/cheaper to compute

Makes use of underwriter's experience & knowledge

Main disadvantage – very subjective (depends on underwriter asked)

Difficult to ensure consistency over time.

Difficult to assess across companies and classes.

Difficult to verify or quantify in detail analytically.

Easy to manipulate – underwriter may have a vested interest or bias.

No audit trail of calculations (for a regulator or auditor).

There may be confusion as to whether a change in the premium is linked to the level of risk or is a rate change.

*No credit for saying this is useful as a check on other methods because question says “relying”.*

*This bookwork part was generally well-answered.*

- (ii) As-if prem(09) =

$$\text{Prem}(09) \times \frac{\text{ILF@Limit}(10) - \text{ILF@Attach}(10)}{\text{ILF@Limit}(09) - \text{ILF@Attach}(09)} \times \frac{\text{Share}(10)}{\text{Share}(09)} \times \frac{\text{Exposure}(10)}{\text{Exposure}(09)}$$

$$= \text{Prem}(09) \times \frac{(2.900 - 2.300)}{(2.750 - 1.000)} \times \frac{23}{20} \times \frac{1,500,000}{1,000,000}$$

$$= £4,900 \times \frac{0.6}{1.75} \times \frac{23}{20} \times 1.5$$

$$= £2,898$$

Hence the change in premium rate from 2009 to 2010 is:

$$\begin{aligned} &= \frac{\text{Prem rate}(10)}{\text{Prem rate}(09)} = \frac{\text{Prem}(10)}{\text{As-if prem}(09)} \\ &= \frac{2,700}{2,898} \\ &= 0.931677 \end{aligned}$$

The true change in rate is  $-6.83\%$

Alternative calculation method:

Total premium for 2009 =  $4900 / 20\% = 24500$

Total premium for 2010 =  $2700 / 23\% = 11739$

ILF for 2009 cover =  $2.75 - 1 = 1.75$

ILF for 2010 cover =  $2.9 - 2.3 = 0.6$

Premium per unit cover 2009 =  $24500 / 1.75 = 14000$

Premium per unit cover 2009 =  $11739 / 0.6 = 19565$

Premium per unit turnover & cover 2009 =  $14000 / 1,000,000 = 0.014$

Premium per unit turnover & cover 2010 =  $19565 / 1,500,000 = 0.013$

Rate change from 2009 to 2010 =  $0.014 / 0.013 = 0.931677$

So the true rate change is minus  $6.83\%$

*Candidates came up with a wide range of approaches and answers to this part, which was surprising given that the first method above appears in Core Reading. Many candidates picked up some credit for an alternative method but then lost their way. Despite the question making it very clear what the extent of cover was, many candidates failed to add the policy limit to the excess to find the upper ILF and ended up interpolating between two values from the table for 2009.*

#### 4 Consider data availability Consider data quality

More years gives more credibility

We want sufficient data to smooth out random volatilities

EL can have very volatile claims experience

We should also consider the **completeness** of the claims data

We need to go sufficiently far back to get:

- The full range of large losses

- Catastrophe type losses
- Experience in some of the more low-frequency rating cells

More heterogeneity in the book means more data required and hence more years

Consider the complexity of the model to be built (e.g. frequency/severity needs more data than aggregate)

Influences on this include:

- The size and age of the company
- Quality and integrity of systems and processes
- Availability of data from external sources

Older years will be less **relevant** to current experience

Examples of losing relevance ( $\frac{1}{4}$  each – max 1):

- big changes in risk or mix of business;
- change in underwriting practice
- changes in claims handling practice
- change in the legal environment for claims
- change in propensity to claims;
- different cover,
- different types of claim;
- more difficult to inflate accurately.

We need a certain number of years to identify **trends**

More recent experience is more **uncertain** (unsettled and non-reported claims)  
Therefore we may drop more recent years

Especially true in a long-tailed class like EL

*This question was quite straightforward and mainly well-covered in Core Reading but generally produced lower scores than the other questions. Candidates tended to regurgitate a limited number of facts about the class of business, rather than trying to answer the question. Most candidates were able to give a range of examples of the lack of relevance of data from older years, but frequently omitted points related to going sufficiently far back to get the full range of losses, cat losses and experience in the low-frequency cells.*

## 5 (i)

- Windstorm/Typhoon/Hurricane/Tropical storm
- Earthquake
- Tornado
- Hail
- Winter storm/Freeze/Snow
- Flood
- Tsunami/tidal wave
- Wildfire/forest fire (or other widespread fire)

- Terrorism
- Pollution (often excluded)
- Nuclear (often excluded)

*This part was generally well-answered but some candidates listed perils that would not be covered in catastrophe reinsurance, such as theft.*

(ii) Reasons

- As with any model, there may be approximations and lack of fit.
- Equally, if the output of the model were the same as actual experience over a long period, this would suggest over-fitting/lack of predictive power.
- The model might be out of date.
- An incomplete event set
  - We may be missing extreme events
  - Some of our exposures may not be adequately covered by the hurricane paths
  - We may be generating from past experience, which does not account for claims trends
  - e.g. in the Gulf of Mexico, due to global warming; economic recession (or other suitable example)
- Errors in the hazard model
  - e.g. wind speed too low, diameter not wide enough
- May under/over estimate potential losses in the vulnerability model
  - For example demand surge may not be sufficiently modelled; or construction types respond unexpectedly; or flood defences perform differently; or other suitable example
- May not model some of the exposures
  - e.g. unusual occupancy or construction type
- Wrong perils switched on in the model
- Coverage not correctly modelled, e.g. flooding excluded
- User input error or mistakes in exposure sheet
- Exposures incomplete
- The model will have been based on expectations of the exposures and mix of business that the reinsurer would take on, but in reality this may turn out to be different.

*No credit for mentioning volatility of underlying claims experience.*

*Candidates did not generally score well on this part because they failed to structure their answer and give a wide enough range of points. The stronger candidates broke their answer down into sections relating to the five sections of a catastrophe model and found that this helped to generate ideas. A significant number of candidates forgot that the three events stated in the question were only an extract of the output, and made comments that it was not appropriate to build a catastrophe model with only three historic events.*

- (iii) Whether each event is covered under the ILW  
The industry loss for each event

(iv)

- For each loss (col (2) above) calculate the recoveries if the ILW were triggered (new Col (5))
- For each event use the industry loss to see if the ILW is triggered
- Multiply the recovery (Col 5) by their frequency and sum up all the triggered rows

*It was evident from answers to (iii) and (iv) that most candidates had a sketchy understanding of the operation of an ILW. In (iii), many candidates gave “industry loss” as an answer but did not say “for each event” and failed to make the first point. Part (iv) was very poorly answered, with most candidates failing to be sufficiently precise to convey understanding.*

6

- (i) incorrect advice  
error in calculation or report

*A surprising number of candidates failed to notice that the question stated the insured is an actuarial consultancy, and suggested perils relating to medical malpractice.*

(ii)

- Limit
- Deductible
- No. of actuaries/employees
- Payroll
- Turnover
- Location of HQ
- Territory of practice
- Claims experience
- Area of practice e.g. GI, Life, Pensions
- Type of work e.g. opinions, reserving, M&A
- Type of client (eg government)
- Additional coverages e.g. public liability (PL), extra contractual obligations (ECO) & excess of policy limits (XPL)
- Exclusions e.g. punitive damages

*This part was generally well-answered.*

- (iii) Claims-made covers all claims first notified within the policy period irrespective of when the event occurred

provided that this is after the retroactive date

On losses-occurring cover claims event must have occurred during the policy period

A claims made policy can be taken out to cover events that may already have occurred



Claims-made basis may give unsatisfactory cover for future claimants where the tortfeasor (i.e. defendant) may cease to exist or cannot obtain cover in the future

*Most candidates gave the definition of claims made and losses occurring but did not give enough further details to gain full marks.*

- (iv) No. of actuaries  
No. of partners  
No. of billable hours

*Many candidates failed to score the full mark because they gave answers that were not suitable measures of exposure or would have to be adjusted for inflation.*

(v)

<i>Policy Year</i>	<i>CM Exposure</i>	
2009	85.175	
2010	87.375	
2011	90.475	$= 95*0.25+90*0.5+86.9*0.25$

*This part was generally well-answered.*

(vi)

<i>Policy Year</i>	<i>CM Exposure</i>	
2009	21.725	$= 86.9*.25$
2010	65.95	$= 90*0.25+86.9*0.5$
2011	90.475	$= 95*0.25+90*0.5+86.9*0.25$

Assumptions:

- No difference in value of claims with longer reporting delay
- Uniform incidence of occurrence of risk(/claims) throughout the exposure year

*Few candidates gave the required assumptions in this part.*

7

(i) Quota share reinsurance:

- Proportional reinsurance
- Claims and premiums shared by an agreed proportion for each risk
- Proportion same for each risk
- Administered by treaty
- May involve an overriding commission (additional commission payable from reinsurer to insurer as a contribution to expenses and profit)
- May also involve a profit commission

- The treaty may specify a limit on the amount of business that may be ceded
- Usually written on a policies incepting basis

*Many candidates wasted time by giving applications of the cover, for which there was no credit.*

(ii)

Year of Account	On-Level	
	Ultimate	Loss Ratio
2008	55.13%	$59\% / ((1-2\%)*(1+5%)*(1+4\%))$
2009	46.70%	$51\% / ((1+5%)*(1+4\%))$
2010	40.95%	$43\% / (1+5\%)$

*A common error in this part was multiplying ULR by the required adjustments instead of dividing.*

(iii) Points:

- Easy to understand/explain
- Has the benefit of being based on actual experience
- However, past experience may not be a good guide to the future
- Profit = premium  $\times$  (1 – exp) – ult. losses
- So to get zero profit we have:
- Loss ratio = 1 – exp = 70%
- i.e. profit is paid out on loss ratios < 70%
- So none of the historic loss ratios would pay out a commission
- This would give a PC load of zero
- This is unrealistic as there must be some chance of paying out
- We only have 11 years of data here. If we had many more we would have the variability to trigger the PC

(iv) Points:

- Probably a good fit to the data, since the mean and variance are sample statistics
- Easy to calculate/apply
- This approach would give a wide variety of results triggering the profit commission, giving a more realistic approach to a long term average
- Aggregate claims distribution tend to be skewed. A normal distribution does not reflect this
- Specifically a normal distribution can go negative and typically does not have a long tail
- However this distribution is very tight and in reality going negative is very extreme
- In addition for PC we're only interested in the distribution below 70% so the tail doesn't matter

- We may wish to give more weight to more recent experience, which this approach does not do
- The past experience might not be a good guide to the future, so the parameters of the distribution may be inappropriate
- In particular, the fact that C has requested a profit commission for the first time suggests a different approach to underwriting in the future

Many candidates misunderstood the operation of the profit commission in parts (iii) and (iv) despite the clear description in the question. Some forgot that it only applied to a single contract and others thought that it was determined using historic experience rather than 2011 performance. In (iii) many candidates concentrated on the long term average loss ratio instead of noting that none of the individual years would have resulted in a profit share being paid. Candidates should note that it is often important to observe the features of the data given in questions.

(v)

$$Z = 1.778 \quad (.86 - .7) / .09$$

Interpolated	$x_i$	$\Phi(x_i)$	$Wt_i$
	1.7700	0.96164	22%
	1.7800	0.96246	78%

$F(x)$	96.23%
prob	3.77%

Many candidates rounded to a value of 1.78 instead of interpolating between 1.77 and 1.78, thereby throwing away easy marks.

(vi) No effect.

Claims and Premiums will be scaled by the same amount.

Most candidates understood that it would have no effect but many were unable to explain clearly why.

8 (i)

Trend Factor	Trended Claims (£)							Number
1.4071	9,850	19,699	49,249	35,178	-	-	-	-
1.3401	95,147	120,609	45,563	-	-	-	-	1
1.2763	104,655	70,195	236,112	66,367	-	-	-	2
1.2155	125,197	29,172	4,862	179,895	269,842	-	-	3
1.1576	19,680	226,895	360,021	6,946	670,265	-	-	3
1.1025	449,820	110,250	67,253	45,203	759,623	429,975	-	4
1.0500	77,700	134,400	242,550	229,950	67,200	55,650	-	3

An alternative and quicker approach (still for full marks) would be to deflate the deductible:

<i>Deflator</i>	<i>Deductible</i>	<i>Number</i>
0.7107	71,068	-
0.7462	74,622	1
0.7835	78,353	2
0.8227	82,270	3
0.8638	86,384	3
0.9070	90,703	4
0.9524	95,238	3

(ii)

<i>Policy Year</i>	<i>% Reported</i>	<i>Ultimate Number</i>
2004	100%	-
2005	100%	1.000
2006	100%	2.000
2007	95%	3.158
2008	90%	3.333
2009	80%	5.000
2010	55%	5.455

(iii) Identify an upwards trend

There are a number of different selections we can make. Sensible selection  
Corresponding explanation

e.g.

- 6–7 frequency is increasing dramatically – extrapolated this
- 5–6 select the most recent experience (seems to be higher than historical)
- 3–5 average over last 4 years (last 2 years may be abnormally poor and '10 is uncertain)

Allow claim frequency per ship instead of per policy

*Parts (i), (ii) and (iii) were all generally well-answered*

(iv) The upward trend in claims may be partly/completely caused by the increase in exposure (ship numbers)

Therefore there may not be a upwards trend of claims/exposure

We need to analyse ultimate frequency (or ultimate aggregate claims) / exposure to identify any trends

This requires obtaining all data on ship numbers or perhaps an alternative exposure measure, such as weight or total insured value

May want to enquire why the increase e.g. new types of business, new locations etc.

*Many candidates suggested that the number of claims should be inflated rather than re-examining claim frequency.*

(v)

- Different deductible levels may affect the reporting pattern because the insured may report smaller claims at a different speed
- This may be applied for a different type of coverage e.g. liability claims excluded
- The mix of business may be different (eg type of ship)
- Insured may transact same type of business but in a territory with different reporting speeds
- The basis for estimating outstanding claims may be different.
- Insured may have different risk attitude or complaints processes, affecting the reporting speed

*This part was answered well by the majority of candidates.*

(vi) Poisson  
Negative binomial

*Most candidates scored full marks for this part.*

(vii) The individual paid plus outstanding claims estimates may need further development (IBNER adjustment)  
Ideally only on open claims  
The resulting distribution may also need adjustment to allow for IBNR

*Many candidates did not make the points in enough detail to score the full mark. Simply saying that the claims needed to be developed was not sufficient.*

(viii)

- Quick and easy approach
- Would expect claim numbers to increase proportionally to exposure
- The new shipping company may have higher or lower expected claims costs than the current company because of:
  - Different types of ships /types of cargo / age of ships / quality of ships
  - Different experience of crew
  - Different territories/legal jurisdiction;
  - Differences in risk management.

- We should be especially wary of the different frequency/severity dynamics here. The 25% method probably assumes frequency per ship and severity per claim are the same for the two companies. If frequency or severity of claims is different, the layered results would be difficult to estimate without remodelling. Conversely there may be a large increase in small claims (under the deductible) but not much on larger ones.
- Ideally we would want all GU claims and historic ship numbers for the new entity
- ...and model the combined company
- Data might not be easily available/reliable
- The expected loss will not be exactly proportional to ship numbers due to the aggregate limit
- Alternatively, the aggregate limit may not be appropriate and may need to be increased
- There may be aggregations that cause diversification to worsen (alternatively, acquisition might increase diversification)
- Larger shipping companies may get a size discount due to better risk management from having specialist risk management departments (made possible due to scale)
- ...however probably too early for this.
- However if acquisition unpopular amongst staff claims may increase e.g. safety officers all leave
- Any additional reinsurance costs might not be proportional (could be higher or lower)
- Any other additional expenses might not be proportional (could be higher or lower)

*This part was not generally well-answered. The better-scoring candidates gave a wide range of points and clear explanations.*

9 (i)  $\mathbf{Y} = g^{-1}(\mathbf{X}\boldsymbol{\beta} + \boldsymbol{\xi}) + \boldsymbol{\varepsilon}$   
 (or  $Y_i = g^{-1}(\sum X_{ij} \beta_j + \xi_i) + \varepsilon_i$ )

where:

$\mathbf{Y}$  is the response vector

$g(\cdot)$  is the link function

$\mathbf{X}$  is the design matrix of factors

$\boldsymbol{\beta}$  is the vector of parameters to be estimated

$\boldsymbol{\xi}$  is a vector of offsets or known effects

$\boldsymbol{\varepsilon}$  is the error term appropriate to  $\mathbf{Y}$

*This part was generally well-answered.*

- (ii) A categorical factor is a factor for which the values of each level are distinct and often cannot be given any natural ordering or score.

A factor which is not categorical is one that takes a naturally ordered value.

*This part was generally well-answered. Some candidates gave an example that applied to motor insurance, which was surprising in a question about household contents.*

- (iii) The scaled deviance and AIC are both statistics used to assess which of two models is the better fit.

If the two models are nested and the scale parameter is known, a  $\chi^2$ -test is used.

The change in scaled deviance ( $D_1^* - D_2^*$ ) is compared with a  $\chi^2$ -distribution with  $(df_1 - df_2)$  degrees of freedom.

If the two models are nested but the scale parameter is not known, an  $F$ -test is used.

The statistic  $(D_1 - D_2) / ((df_1 - df_2)(D_2 / df_2))$  is compared with an  $F$ -distribution with  $(df_1 - df_2, df_2)$  degrees of freedom.

If the two models are not nested, the AIC is used  
where  $AIC = -2 * \text{loglikelihood} + 2 * \text{number of parameters}$

The model with the lower AIC is said to have the better fit.

*This part was generally well-answered. However, few candidates mentioned the  $F$ -test.*

- (iv) Models 1A and 1B are subsets of Model 0 so comparisons with Model 0 should use the scaled deviance.

The difference in scaled deviance for Model 1A = 1.1  
and the difference in degrees of freedom = 1.

The upper 5% point of  $\chi^2_1$  is 3.841 and  $1.1 < 3.841$  (equal credit for calculating a  $p$ -value of around 0.3)

So Model 1A is not significantly different from Model 0 and so we would conclude that the “occupied during the day” indicator is not a significant factor.

We would reject Model 0 in favour of Model 1A.

The difference in scaled deviance for Model 1B = 11.3  
and the difference in degrees of freedom = 6.

The upper 5% point of  $\chi^2_6$  is 12.59 and  $11.3 < 12.59$  (equal credit for calculating a p-value of around 0.08)

So Model 1B is not significantly different from Model 0 and so we would conclude that the “property type” indicator is not a significant factor.

We would reject Model 0 in favour of Model 1B.

Models 1A and 1B are not nested but a further comparison between these can still be done using AIC.

The AIC for Model 1A is lower than that for 1B, suggesting that Model 1A is preferred.

Dropping property type in 1B does not appear as successful as dropping “occupied during the day” in 1A.

AIC includes a penalty for the number of parameters. Although dropping property type removes a larger number of parameters from the model (six as opposed to just one), it has more influence on the fit of the model, so the AIC is poorer for 1B.

It is perhaps surprising that these rating factors are not more significant, which suggests that other factors are acting as proxies, or that there may be an error in the data or model.

*A large number of candidates used the wrong number of degrees of freedom for the  $\chi^2$  tests. Even of those who calculated the test statistic correctly a considerable number drew the wrong conclusion from the results of the tests.*

## **END OF EXAMINERS' REPORT**



# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

26 April 2012 (pm)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all eight questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p>
--

**1** A general insurance company is considering whether to transfer the liabilities from a particular class of business using some form of run-off reinsurance.

(i) Outline:

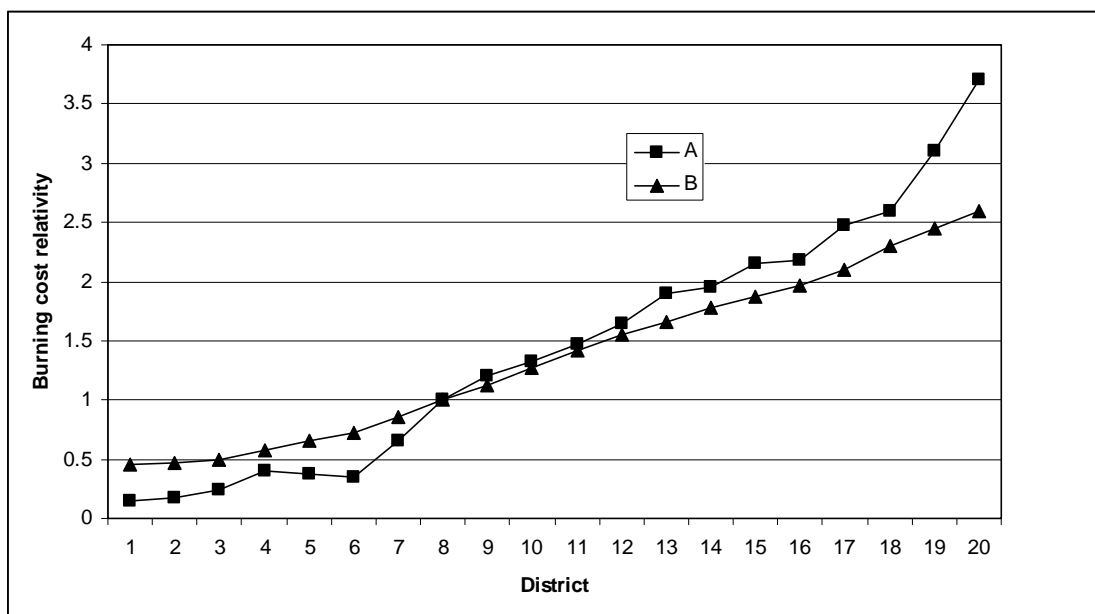
- (a) the aims of run-off reinsurance.
- (b) the circumstances in which it might be used.

[2]

(ii) Describe the two main types of run-off reinsurance that could be used. [6]  
[Total 8]

**2** A large general insurance company uses multivariate techniques to reallocate every UK postcode to one of 20 districts for its motor book. A postcode is allocated to a particular district based on its expected claims cost, where district 1 contains postcodes with the lowest risk and district 20 contains those with the highest risk.

There is a lot of uncertainty, especially around postcodes with little or no past exposure, and so the insurer has produced two alternative sets of district allocations, A and B. For each of A and B a GLM has been created, in which all factors other than district are identical. From these models a graph has been constructed showing the burning cost relativities for each district, for each of A and B:



Each of the districts contains the same amount of past exposure in each allocation.

Discuss the factors that the company would consider and the analysis that it would carry out when deciding which of the two district allocation models to implement into the pricing structure.

[9]

- 3** A particular class of business has exactly  $n$  policies. It is assumed that the number of claims ( $N$ ) follows a binomial distribution and that the individual claim amounts ( $X_i$ ) are discrete random variables taking positive integer values.  $S$  represents the aggregate claim amount.

You are given Panjer's recursion formula:

$$g_0 = p_0$$

$$g_r = \sum_{j=1}^r (a + bj/r) f_j g_{r-j} \quad \text{for } r = 1, 2, 3, \dots,$$

where

$$g_k = P(S = k),$$

$$p_r = P(N = r)$$

and

$$f_k = P(X_i = k).$$

Show, using Panjer's recursion formula, that

$$g_0 = q^n$$

and

$$g_r = \sum_{x=1}^r \frac{p}{(1-p)} [(n+1)x-1] f_x g_{r-x} \quad \text{for } r = 1, 2, 3, \dots$$

[7]

- 4** A general insurance company is reviewing its pricing for a large book of personal lines business. It proposes to set its prices so that their average, over a representative basket of risks, is always within 5% of the average price of a specified competitor over the same basket. The competitor's prices are to be obtained in the open market.

(i) Discuss the merits of this proposal. [8]

(ii) Suggest the questions that could be raised in order to refine the proposal. [3]

[Total 11]

- 5** (i) State the factors to consider when selecting an increased limit factor (ILF) curve for a pricing exercise. [5]

A general insurance company needs to price a professional indemnity policy for an accountancy firm. It has two ILF curves, appropriate for accountants. The numerical values of the curves are given in the table below.

<i>\$m</i>	<i>A</i>	<i>B</i>
0.00	0.00	0.00
0.25	0.50	0.40
0.50	0.75	0.70
1.00	1.00	1.00
2.00	1.35	1.50
5.00	2.00	2.50
10.00	2.50	3.50

- (ii) State how the claims distributions underlying curves A and B differ. [1]
- (iii) Suggest reasons why the claims distributions may vary by accountancy firm. [3]

An initial claims analysis of the layer \$0.5m excess of \$1m gives an expected loss cost of \$250,000. The company wishes to obtain the loss cost of a higher layer using the ILFs.

- (iv) Derive, using each curve separately, the expected loss for a \$2m excess of \$6m layer, using linear interpolation where necessary. [3]
- [Total 12]

- 6** (i) Describe the characteristics of Lloyd's syndicates. [4]

A binding authority contract allows a third party (the coverholder) to write a number of risks on behalf of an insurer.

A Lloyd's syndicate writes an annual insurance contract through a binding authority. The contract is due for renewal on 1 June 2012. The following data have been provided:

<i>Year of Account</i>	<i>Premium net of commission</i>	<i>Commission</i>	<i>Incurred Claims</i>
2007	4,230	15%	3,620
2008	4,200	15%	380
2009	5,500	20%	1,020
2010	5,430	20%	1,600
2011	4,640	20%	1,960

Values are in \$000 and are as at 31 March 2012. Premium income is received evenly throughout the year.

The following assumptions have been provided:

<i>Year of Account</i>	<i>Incurred % of Ultimate as at 31 March 2012</i>	<i>Rate Change on Previous Year</i>
2007	87%	
2008	75%	–10%
2009	62%	–5%
2010	45%	0%
2011	25%	5%

where rate change is the change in gross premium, i.e. before the deduction of commission.

- Rate change from 2011 to 2012 is to be zero.
  - The effects of claims inflation can be ignored.
  - The 2012 commission rate will remain at 20%.
- (ii) Derive ultimate loss ratios for each year of account, net of commission and at a 2012 rating level. Use a Bornheutter-Ferguson method for the 2011 year of account with a prior loss ratio (net of commission) of 55%. [10]
- (iii) Estimate the underlying contract ultimate loss ratio, net of commission and at a 2012 rating level. [1]  
[Total 15]

**7** A general insurance company writes pet insurance. This insurance covers the cost of vets' fees for household pets in the event of an accident or illness.

- (i) List the data fields that you would expect to be included within an information system used solely for pricing pet insurance. [5]

The company has recently taken over a book of pet insurance from another insurer and wants to transfer the new rating and administrative data onto its own systems.

- (ii) Describe the problems it might encounter with integrating the data, and the possible consequences. [12]  
[Total 17]

8 (i) Describe the features of catastrophe excess of loss reinsurance. [4]

(ii) State why an insurer might buy this type of reinsurance. [3]

A reinsurance company writes catastrophe excess of loss reinsurance. The relative merits of two different contracts for the same cedant need to be investigated. The cedant has given an output from its catastrophe models. The output shows stochastically generated events, losses to the cedant and the year in which they arise. An extract is given below:

<i>Year</i>	<i>Event No.</i>	<i>Cedant Loss (£m)</i>
.....		
467	954443	20.3
467	954444	3.5
467	954445	0.3
467	954446	13.1
468	954447	15.0
468	954448	50.7
468	954449	32.4
468	954450	2.9
469	954451	11.3
.....		

(iii) Suggest questions to ask the cedant about this output. [5]

The two alternative proposed layers are:

Layer 1: £5m excess of £10m at a rate on line of 0.2

Layer 2: £20m excess of £10m at a rate on line of 0.12

Both layers have one free reinstatement.

(iv) Derive the contributions to losses to each layer from each of the years 467, 468 and 469. [4]

Carrying out the exercise on the full event set produces average annual losses as follows:

Layer 1: £0.5m

Layer 2: £0.8m

(v) Derive:

(a) the loss ratio of each layer.

(b) the implied loss ratio of the layer £15m excess of £15m, assuming that pricing is consistent with layers 1 and 2.

[2]

Suppose the reinstatement premiums are changed to be paid at 50% of the original premium.

- (vi) Describe how to derive the revised rate on line for layer 1 to maintain the same expected loss ratio. [3]  
[Total 21]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

April 2012 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Purpose of Examiners' Reports**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

T J Birse  
Chairman of the Board of Examiners

July 2012



## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the April 2012 paper**

The level of difficulty of the paper and the general performance of candidates were very similar to recent sittings. A number of well-prepared candidates scored strongly and displayed a good understanding of the subject across the whole paper. There was some evidence of time pressure amongst candidates around the pass-mark area, but this certainly did not appear excessive. Failure to show workings in numerical and algebraic answers was a recurrent theme in this sitting. Candidates should note that the examiners cannot award any marks where the final answer is incorrect and workings are missing or unclear. However, marks can be awarded for partially correct workings where these are shown clearly.

Q3 contained an error in a mathematical formula on the paper, making it impossible for candidates to prove the result. This error only affected the final stages of the proof, worth one mark, and it was interesting to note that many candidates did not get anywhere near the point where the error would have caused them a problem. The approach taken to compensate for the error was to scale up any marks credited for the remainder of the solution, so that candidates could still obtain full marks for the question.

Nearly all of the questions produced a good range of scores, but Q4 and Q7 had a lower range than the remainder. The very last part of Q8 was designed to stretch the better candidates, but in fact this was very poorly attempted overall.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to concentrate their revision in these areas.

- 1** (i) (a) Aims:  
to transfer reserve development risk  
i.e. to cover the volatility arising from past activities.
- (b)
- when reinsuring to close a Lloyd's syndicate year of account
  - when winding up a company
  - corporate restructuring (or change in strategy)
  - capital restructuring (or to free up capital for new business)
  - mergers and acquisitions
  - closing lines of business (leading to loss of expertise)
  - where a reinsurer can run off the business more cheaply
  - economic changes in the value of the liability
  - regulatory, accounting or tax changes
  - legal developments
  - for example, court decisions

*This bookwork part was generally answered well. Better candidates drew out the distinctions between run-off reinsurance and other types; poorer answers could have been applied to any type of reinsurance.*

(ii) **Adverse Development Cover**

In return for a premium, the reinsurer agrees to cover the ultimate settled amount of a specified block of business above a certain pre-agreed limit.

This may be greater than the current level of reserves.

The premium payable will depend on the risk appetite of the market.

There could be an upper limit too i.e. the insurer is still liable for the excess.

The reinsurer may also insist that the insurer has a small participation in the layer

Claims are still handled by the insurer.

Reserves are maintained by the insurer.

So the insurer still bears the associated expenses and receives investment income relating to the claims and reserves.

The insurer remains legally liable to the insured parties and is exposed to the credit risk of the reinsurer.

**Loss Portfolio Transfers**

The whole liability for the book of business is passed from the current insurer to the new insurer, so the new insurer is totally responsible for the liabilities from the date of transfer.

Therefore, an LPT is not strictly reinsurance.

Policyholders will be informed of the transfer.

The transfer may need court approval.

The reserves are transferred, along with the remaining exposure plus, possibly, an extra premium.

The new insurer receives the future investment income and claims risks.

The new insurer would normally handle the future claims.

*Many candidates made a good attempt at this part. The main reason for losing marks was simply not writing enough points. However, there were also common misunderstandings. Many candidates were unclear how each type of reinsurance was financed, i.e. a premium is payable for ADC, whereas LPT primarily involves the transfer of reserves. Confusion often appeared over the loose use of terms "reserves", "assets", "investments" and "liabilities", which conveyed a lack of understanding. Several candidates contradicted themselves by implying that they were considering ordinary reinsurance, such as referring to future premium income.*

## 2 The most important consideration is the degree of fit to the expected future experience.

Degree of fit can be tested using formal statistical tests in the modelling process. e.g. Akaike Information Criterion, or other valid test (not chi-square, as models are not nested)

There might be a rapid trend over time towards either A or B.

A time consistency check involves interacting the district with a time-related factor and looking for a trend.

Another check is to subdivide by a random factor.

The degree of uncertainty of the model parameters can be assessed by calculating standard errors of the parameter estimators.

The spread of relativity values across districts can be combined with their standard errors to check that their error ranges do not overlap too much.

Over-fitting is a danger because this causes the model to lose predictive power.

A check on this is to withhold some data from the sample used to fit the model and perform tests on the model's fit to the withheld data (or use an out-of-time dataset).

Cook's distance can be used to see whether any data points have an undue influence over the choice of A or B.

e.g. young drivers in urban areas, or a large liability claim.

Model A's graph is steeper than B's, so A differentiates more between good and poor experience for this factor.

However, more discrimination between risks is only helpful if the fit is also better.

A lift curve could be constructed to compare the predictive power of A and B on an out-of-sample dataset.

One method is to rank all out-of-sample data by expected burning cost for each model separately, then plot a graph of actual experience against each of those rankings on the same chart, using the same exposure scale. The steeper the curve, the more effective the model is at distinguishing high from low burning cost.

A gains curve can also give information on the value added by the district classification.

With this method the data is sorted high to low according to the fitted model values and a graph can be plotted to show the cumulative values of the fitted model and the

observed values from the data against cumulative exposure. This could be done for each of A and B.

The Gini coefficient can then be calculated to provide a statistical measure for the lift produced by the model. This can be thought of as the area enclosed by the model curve and the diagonal line as a ratio of the triangle above the diagonal.

Curve A is not as smooth as curve B, so we may wish to smooth/adjust it before using it.

We should beware of smoothing too much, as this will reduce fit.

Curve A slopes the wrong way for districts 4 to 6, so this may need to be looked into further and adjusted for.

We would need to consider the market's approach to this factor, i.e. do some market comparisons for various postcodes, because we might not want to be too far out-of-line for policies in our target market and/or we may not need to be as cheap for postcodes in the low districts.

Consider how our mix of business might change in the future depending on which of the two district allocations we choose.

We would also need to consider the extent of the change from the existing district structure, e.g. by plotting it on the same graph, for comparison, and particularly the impact on customer price, e.g. identify where large swings in prices are expected.

How practical is it to implement either structure (ie, is one more complicated than the other)?

Will either structure result in large jumps in premium for a small change in distance (risking customer dissatisfaction)?

Does the choice of A or B make a significant difference to the overall model?

*Some candidates made a very good attempt at this question by looking at a wide range of ideas, including the fit with the existing structure and impact on competitive position. However, many candidates appeared not to understand the aim of the question and did not generate sufficient relevant points. The following were common errors:*

- *Discussing how to carry out GLM analysis or types of spatial smoothing in order to derive district allocations, even though the question states that these allocations had already been prepared.*
- *Assuming that the steeper relativity curve (A) must be a better fit to the data because it discriminates more between rating areas.*
- *Stating that the amount of exposure in each point should be examined, even though the question states that this is not necessary.*
- *Writing at length on theory of GLMs and failing to consider the actual curves in the question.*
- *Writing at length about spatial smoothing.*

- 3** From the Tables (p17): For an integer-valued distribution, an underlying assumption of Panjer's formula is that there are numbers  $a$  and  $b$  such that:

$$p_r = (a + b/r) p_{r-1} \quad \text{for } r = 1, 2, 3, \dots$$

From the Tables (p6), for the binomial distribution,

$$p_r = \binom{n}{r} p^r q^{n-r} \quad \text{for } r = 0, 1, 2, \dots, n$$

so

$$\begin{aligned} \frac{p_r}{p_{r-1}} &= \frac{\binom{n}{r} p^r q^{n-r}}{\binom{n}{r-1} p^{r-1} q^{n-r+1}} \\ &= \frac{n!}{r!(n-r)!} \cdot \frac{(r-1)!(n-r+1)!}{n!} \cdot p q^{-1} \\ &= \frac{(r-1)!}{r!} \cdot \frac{(n-r+1)!}{(n-r)!} \cdot \frac{p}{q} \\ &= \frac{(n-r+1)}{r} \frac{p}{q} \\ &= \frac{(n+1)}{r} \frac{p}{q} - \frac{p}{q} \end{aligned}$$

Setting

$$a + \frac{b}{r} = \frac{(n+1)}{r} \frac{p}{q} - \frac{p}{q}$$

gives

$$a = \frac{-p}{q}$$

and

$$b = \frac{(n+1)p}{q} \quad \text{or} \quad \frac{(n+1)p}{(1-p)} \quad \text{where } q = 1 - p$$

Substituting into Panjer's formula gives:

$$g_r = \sum_{x=1}^r \left[ \frac{-p}{(1-p)} + \frac{(n+1)px}{(1-p)r} f_x g_{r-x} \right] \text{ for } r = 1, 2, 3, \dots$$

$$= \sum_{x=1}^r \frac{p[(n+1)xr^{-1} - 1]}{(1-p)} f_x g_{r-x} \text{ for } r = 1, 2, 3, \dots$$

as required.

*Note that the above formula appeared incorrectly in the question paper.*

$g_0$  can occur if and only if  $N = 0$   
i.e., if  $P(N = 0) = p_0$

$$= \binom{n}{0} p^0 q^n$$

$$= q^n$$

as required.

*Some students omitted this question altogether, or made no serious attempt at it. Those who did attempt it generally did quite well, with a high proportion getting full marks. Most candidates were at least able to show that  $g_0 = q^n$ . Poorer candidates threw away marks by making trivial arithmetical mistakes, compounded by showing little working, making it difficult for examiners to give any credit for interim steps.*

#### 4 (i)

- It is helpful to be aware of competitive position because it helps to estimate impact of price changes on volumes and income.
- The method could work well if the product has few rating factors.
- Tracking the market may be useful if some of the individual products have only small volume, or history is unavailable (e.g. book was purchased or taken over), or if the basket of risks includes new areas of risk.
- However, this "large" book should have good enough volume of data for using own experience.
- Failure to use the company's own experience may result in a higher capital requirement, or a higher reinsurance cost.
- There could still be enough scope for variation between the company's prices and the competitor's, even if the average is similar.
- Or it might not be tight enough to attract enough customers if the class of business is very competitive.
- It might be better to use more than one competitor to avoid large price swings.

- The constraint on pricing strategy could erode profitability overall (ie be sub-optimal) in the following ways:
  - Writing some risks at unprofitable rates.
  - Losing business by charging too much for some risks.
- The price comparison may be distorted/invalidated by:
  - Product features and benefits not being identical.
  - Periods of time in which the competitor is running a special promotion.
  - Insufficient volumes in the basket of risks.
  - A small number of very high prices skewing the average.
  - Differences between insurers, such as expense base, reinsurance structure.
  - Strategy of the competitor, such as loss leaders or desire for growth.
- If open-market prices are readily available then it could be a quick and easy method of setting a price.
  - However, it could be time-consuming and expensive because telephone and face-to-face channels must be worked manually, and internet sites may have anti-screen-scraping measures.
- Some prices may not be visible at all, for example negotiated discounts, affinity or loyalty discounts.
- If the company wants to apply the approach for renewals as well as new business, reliable renewal prices will be almost impossible to obtain.
- There may be legal issues with obtaining the data, such as legislation on accessing websites, mystery shopping or competition law.
- Prices could become out-of date very quickly.
- If the two insurers represent a large share of the market, this practice could amplify the insurance cycle.
- The practice could become known to the public, which could erode consumers' confidence in the industry or give rise to an investigation by the authorities.

(ii)

- What are the objectives and perceived problems that have led to the % constraint?
- How was the 5% figure arrived at (or why do they think that 5% is the right number)?
- Is the class of business profitable for the competitor at current prices?
- How was the competitor chosen?
  - E.g., are they a market leader in pricing capability?
- What will happen if the competitor changes its market position radically (e.g. exits a line of business)?
- How will the basket of risks be defined?
  - which classes of business;
  - which channels (telephone, internet, face-to-face);
  - extent of coverage (footprint), e.g., excluding unusual risks;
  - what volume of risks;
  - what combinations of cover options;
  - how often will the definition (not the prices) be refreshed.
- How frequently will the comparison be made?
- How will the average price be calculated?

- just one average price or broken down by channels and cover types;
- how should missing prices be treated;
- how often will the competitor price data be collected;
- what weightings will be used.

*Candidates generally answered this question poorly, either because of the way they interpreted the question or because they did not generate enough ideas.*

*Some candidates appeared to interpret the use of the word “merits” in this question to assume examiners were only looking for positive aspects of this approach. A surprising number of candidates appeared to assume that the price for every individual risk would be set within 5% of the competitor’s price, going on to claim that this would eliminate the risks of anti-selection.*

*Many candidates wasted time by talking about how the proposal makes the pricing process easier or quicker, simply repeating themselves by doing so, without thinking of valid reasons why it could be used (low volumes of past data etc). Many came up with spurious advantages (it would boost volumes, inspire customer loyalty etc). Few mentioned why it may be useful in terms of a new area of risk, lack of volume, lack of history etc. Fewer still thought of mentioning legal issues and the difficulties that may arise with obtaining competitor price information.*

*Part (ii) was often just a repeat of what was written in part (i). Examiners gave credit under Part (i) for distinct points made under Part (ii) and vice versa, but not where the same point was repeated.*

- 5** (i) It is important to pick a curve that is most representative of the firm being priced  
i.e., appropriate to the class of business and type of cover,  
but still keep in mind that adjustments might be needed.  
In practice, the choice will depend on which curves are available.

Factors to consider when selecting/adjusting:

- Whether the assumptions for the theory to hold are valid, i.e.:
  - ground up loss frequency is independent of limit purchased;
  - severity is independent of number of losses and limit purchased.
- The amount of experience we have of losses for the particular firm compared with the other data available (i.e. credibility considerations).
- Treatment of loss adjustment expenses:
  - allocated (ALAE);
  - unallocated (ULAE).
- Loading for volatility or “risk”.
- Nature of limits to cover for this risk compared with the curve assumptions, e.g. per claimant/per occurrence.
- Whether the curve is appropriate to the jurisdiction or claims environment.
- Effects of trends in the claims environment and whether these are reflected in the curves.



- Effect of claims inflation and whether reflected in the curves.
- Particularly as a result of legal reform.
- How up-to-date the curve is.
- ILF absolute limit values may need to be adjusted for the period between derivation and prospective period of cover.
- Which curves are generally used in the market (if available).

*This part was generally answered well by candidates who knew their bookwork. However, many made their points too briefly, e.g. just writing "inflation", which made it difficult to award any marks. A number of candidates wasted time by explaining what they would need to do in order to build an ILF curve from their own data, which was not required.*

- (ii) There are more larger claims in curve B than in curve A relative to smaller claims (ie fewer smaller claims).

*This part was answered well by candidates who understood the mechanics of ILFs. However, many candidates failed to realise that the ILF curve can only show relative claim distributions. Concluding that B would give rise to more claims than A (since it takes a value of 3.5 at a \$10m limit vs 2.5 for A) would be erroneous. Some just drew or described the curves given, rather than answer the question about what the shape of the curves inferred about the claims distributions.*

- (iii) Possible differences in:

- Risk management culture and governance practices in the firm.
- Skill and experience of the firm's employees.
- Domiciled territories of the firm (location of its registered office).
- Practising territories of the firm.
- Areas of practice of the firm (e.g. audit, tax etc).
- Types of client that the firm has (e.g. government).
- Size of firm (e.g. no. of staff or turnover).
- Extent and type of coverage of the insurance (e.g. punitive damages covered)
- Size of projects/contracts that the firm has with its clients.
- Indemnity limits applied in agreements between the firm and its clients.

*This was an opportunity to demonstrate an understanding of what drives risks in the real world and was answered well by the majority of candidates.*

(iv)

**A**

ILF (\$.5m xs \$1m)	$0.5 \times 1.35 + 0.5 \times 1 - 1$ 0.17500
ILF (\$2m xs \$6m)	$(0.6 \times 2.5 + 0.4 \times 2) - (0.2 \times 2.5 + 0.8 \times 2)$ 0.20000
ILF (Base to Policy)	0.2/0.175 1.14286
Policy loss cost	$250 \times 0.2 / 0.175$ 285.71429

**B**

ILF (\$.5m xs \$1m)	$0.5 \times 1.5 + 0.5 \times 1 - 1$ 0.25000
ILF (\$2m xs \$6m)	$(0.6 \times 3.5 + 0.4 \times 2.5) - (0.2 \times 3.5 + 0.8 \times 2.5)$ 0.40000
ILF (Base to Policy)	0.4/0.25 1.60000
Policy loss cost	$250 \times 0.4 / 0.25$ 400.00000

*This part was generally answered well. Common mistakes included:*

- *Calculating the two separate ILF curves correctly but then using an incorrect method to obtain the loss cost.*
- *Confusing \$2m XS of \$6m with \$6m XS of \$2m.*
- *Arithmetic slips with no intermediate working shown.*

**6**

(i)

- A group of Lloyd's Names who collectively co-insure risks.
- Names can be individual or corporate.
- Syndicates often focus on heavy commercial, reinsurance or specialist classes.
- Each syndicate appoints a managing agent to run its insurance operation.
- The syndicates employ underwriters to write insurance business on behalf of the members.

- Syndicates are authorised and governed by Lloyd's.
- Each member contributes capital to the syndicate.  
and accepts portions of the risk proportional to their capital.
- Profit and loss is shared amongst the members in these proportions.
- The member's share of a syndicate is fixed during an underwriting year, but may change from year to year.
- Lloyd's syndicates have access to Lloyd's global licences.  
enabling them to write business almost anywhere in the world.

Candidates generally scored well in this part, with most being able to generate plenty of points on the workings of Lloyd's syndicates. However, many went into detail regarding other aspects of Lloyd's, such as 3-year accounting, which was not required.

(ii) Calculating on-level gross premium

<i>Year of Account</i>	<i>Gross Premium</i>	<i>Ultimate Gross Premium</i>	<i>Rate Index</i>		<i>On-level Gross Premium</i>
2007	4,976	4,976	0.8978	$0.9975 \times (1 + -0.1)$	4,468
2008	4,941	4,941	0.9975	$1.05 \times (1 + -0.05)$	4,929
2009	6,875	6,875	1.0500	$1.05 \times (1 + 0)$	7,219
2010	6,788	6,788	1.0500	$1 \times (1 + 0.05)$	7,127
2011	5,800	6,960	1.0000		6,960

5800\*12/10

Projecting gross loss ratios

<i>Year of Account</i>	<i>On-level Gross Premium</i>	<i>On-level Net (20% brokerage) Premium</i>
2007	4,468	3,574
2008	4,929	3,943
2009	7,219	5,775
2010	7,127	5,702
2011	6,960	5,568

<i>Year of Account</i>	<i>IDM</i>	<i>Ultimate Claims</i>			<i>On-Level Net Ult LR</i>
		<i>BF prior</i>	<i>BF emerging</i>	<i>Selected</i>	
2007	4,161			4,161	116.4%
2008	507			507	12.9%
2009	1,645			1,645	28.5%
2010	3,556			3,556	62.4%
2011		3,062 (=55%*5568)	2,297 (=0.75*3062)	4,257 (=1960+2297)	76.5%

*Candidates generally dealt with this question quite well, but very few got close to scoring full marks. Candidates scored most highly where workings were shown clearly. Most candidates were able to calculate gross premium and on-level gross premium, as well as ultimate claims up to 2010. However many made a mistake when calculating on-level net premium, by taking off brokerage for that particular year rather than the flat 20%. Nearly all candidates ignored the fact that the data was at March, so the final year's premium needed to be grossed up by 12/10 to get the ultimate premium. A significant number were unable to use the BF method for ultimate claims in 2011.*

(iii) Selecting 2012 Ultimate Loss Ratio

LR (net of comm.)	57.5%	(Volume All Average)
	59.3%	(Simple All Average)

*Most candidates were able to use a suitable average, or censored some data with clear explanation, both of which were acceptable.*

**7** (i)

**Policy details**

- cover level (there might be a choice of limits or insured illnesses)
- excess points (current and historic)
- type of pet (cat/dog/rabbit/horse etc.)
- dates of cover (start, end)
- dates of any changes in cover
- details of any specific exclusions
- premium amounts (written)
- premium payment method/frequency
- policy number
- name of pet or pet identifier

**Rating factors**

- postcode / area / location
- Breed (including pedigree/cross flag)
- Age/DOB
- Gender
- Neutered/spayed
- Pet weight
- Owner's attributes (e.g., age, occupation)
- Sales channel
- Number of other pets
- Identity tagged/chipped
- NCD/past claims
- Pre-existing conditions

- other valid rating factor

### **Claims details**

- unique claim ID
- link to policy details
- claims amounts paid and dates
- excess
- payment type (indemnity, fees etc)
- outstanding amounts and dates
- currency
- rating factors at time of claim
- date of claim event
- date claim made (reported)
- open/closed/reopened indicator
- date closed (if applicable)
- cause/type of claim (e.g. type of illness)
- location of vet

*Candidates were generally able to list many points in this part. However, many made no mention at all of claim details or else just mentioned it briefly in relation to policy details. Some were unable to come up with sensible rating factors for pet insurance.*

(ii)

### **Data Definition Problems**

The data could be of poor quality, e.g. missing, or containing lots of errors. It might not be detailed enough. For example:

- insufficient data fields or too grouped
- they may not collect information on rating factors that we use
- the other insurer might capture different data items to us – for example, dog breed group rather than exact breed.

If the other company sells through brokers who do lots of the admin of policies and/or claims then the data might be less detailed.

If the other company uses more than one distribution channel then the data might come in lots of different formats depending on the channel.

This could create a need to contact the policyholder prior to renewal, to get the required information, or a need to make assumptions when calculating premium rates. The data might be in a very different format from ours, e.g. policy numbers might have a different format.

The definition of a claim might be different. For example, for ongoing health problems where a pet needs treatment every month, are the monthly claims treated as separate claims or linked together as one?

If this definition differs for the two insurers then the calculated frequencies and severities won't be comparable.

There could be different treatment of expenses & fees or excesses.

Inconsistent claims estimate methods underlying the data.

The above problems could lead to:

- Incorrect information on performance of the book, leading to incorrect management decisions.
- Loss of profits through pricing too low
- Loss of profitable volume through pricing too high.
- Antiselection through using an incorrect rating structure.
- Inappropriate reserving.
- Incorrect capital held, leading to possible solvency problems or regulatory intervention.
- Failure to make recoveries from reinsurers.

### **Processing Problems**

Policies may have features that can't be accommodated in our system.

So we either have to build it in or change the policy, which either costs IT money or risks attrition.

The two systems may be incompatible i.e. not able to link up for the purposes of transferring data.

We may need to maintain two different sets of systems, leading to extra ongoing costs, or spend time and money finding a suitable IT solution, or manually transfer data, which could be open to errors.

Data volumes may overload the system.

There may be "pipeline" problems with transferring records that are partway through a transaction, such as a purchase, renewal or claim.

In these cases the transfer may omit historical information that is needed to close the transaction properly.

Payment processing to customers, refunds, commissions, aggregator fees etc: we need to ensure these are not missed or duplicated.

Currency treatment might be inconsistent.

If the imported policy is for a customer we already have (with a different type of policy), then we will need to synchronise the customer record.

Similarly with claims supplier records.

The consequences of the above may be incorrect payments to customers or suppliers; poor customer service and loss of reputation.

### **Legal Problems**

Customer data may be subject to data protection laws, which may limit the use of data.

Contravening these laws could lead to criminal prosecution and unfavourable publicity, so permission may need to be obtained for use of personal data when a policy is issued or renewed.

*The focus of this part was on problems in integrating data and was quite poorly answered relative to other questions on the paper. Some candidates focused too much on one particular area (for example, all the errors there could be in a given dataset); others went off at a tangent (for example, covering in great depth how to deal with data problems in subsequent GLM analysis). Few candidates came up with sufficient distinct ideas to score well, and only a small number gave sufficient points on the consequences of data integration problems.*

8

(i)

- Reinsurer agrees to indemnify the cedant for an amount above an excess.
- Cover is up to a specified limit.
- Cover is non-proportional.
- It is a form of aggregate XoL.
- It is used for very high aggregate losses.
- Coverage is for an accumulation of losses due to a specific event.
- For example, storm, flood, freeze.
- Event length limited via an hours clause.
- Hours clause is commonly 24 or 72 hours (96 for freeze) (*one of these is sufficient to score*)
- Cedant chooses start point of period.
- Usually an insurer will have a stack of layers.
- There may be reinstatements.
- The excess point and upper limit may be indexed in a stability clause.
- The policy is normally renewable annually.
- Cover is provided under a treaty.

*This part was generally answered well.*

(ii)

- Allows insurer to accept risks that could lead to large claims.
- Reduces the risk of insolvency from a catastrophe.
- Mitigates concentrations of risk.
- Stabilises the technical results of an insurer by reducing claims fluctuations i.e. smoothes profits.
- This can assist with business planning.
- Helps make more efficient use of capital by reducing the variance of the claims payments.
- Lower the regulatory capital.
- May be better value than alternatives.
- Can improve financial strength (eg in the view of ratings agencies).
- May be a regulatory requirement.
- Increase capacity to write a greater volume of business.

*This part was generally answered well.*

(iii)

- What cat model is used (e.g. proprietary/internal)?

- What version of the model is used (or how up-to-date is it)?
- Is secondary uncertainty modelled?
- What are the key areas of uncertainty in the model?
- Which perils are modelled?
- Which territories are modelled?
- Is the exposure complete/reliable?
- How recent is the exposure data?
- Is the exposure data likely to change materially over the period of coverage?
- Are losses after all other reinsurances?
- What options are turned on, e.g. demand surge, business interruption, fire following quake, storm surge?
- What is the definition of “year”?
- What are the definitions of the events?
- What are the probabilities or return periods of the events?
- Is the loss amount the ground-up, uncapped amount?
- Is the loss amount indemnity only, or are other elements included?
- What currency conversion rates have been used?
- What hours clause has been assumed?

*This part was generally answered quite well, but some candidates scored poorly, being unable to come up with enough ideas.*

(iv)

Xs	10	10
Lim	5	20

<i>Event No.</i>	<i>Layer 1</i>	<i>Layer 2</i>
954443	5.00	10.30
954444	–	–
954445	–	–
954446	3.10	3.10
954447	5.00	5.00
954448	5.00	20.00
954449	5.00	20.00
954450	–	–
954451	1.30	1.30

*Equivalent credit was awarded if effect of reinstatements was calculated in the above.*



Year	Unlimited		Limited	
	Layer 1	Layer 2	Layer 1	Layer 2
467	8.1	13.4	8.1	13.4
468	15.0	45.0	10.0	40.0
469	1.3	1.3	1.3	1.3

Assumption: cover is annual, so there is one reinstatement per year.

Most candidates made a reasonable attempt at this part. Common mistakes included:

- Confusion over what £5m XS of £10m would pay out, and when.
- Failure to allow for the reinstatement, or to limit the policy to only one reinstatement.
- Confusing the mention of “rate on line” with lines of cover (as in surplus RI).

Candidates who showed their workings could recover marks despite minor slips, such as arithmetical mistakes. Candidates who failed to do this tended to forfeit valuable marks for small mistakes.

(v) (a)

AAL	0.5	0.8
Premium	1.0	2.4
	=5*0.2	=20*0.12
RI LR	50%	33%

(b) Since Layer 1 is a subset of Layer 2, the implied loss ratio for the layer 15 xs 15 is  $0.3 / 1.4 = 21\%$

Relatively few candidates realised that £15m XS of £15m was the difference between the layers being priced in the question.

(vi) The average annual loss of £0.5m will include some years where the cover was completely burnt through for the first time and some where there was only partial use of the cover or none at all.

The treaty will specify the mechanics of reinstatement, which would normally be after each recovery (pay-as-you-go). Although not market practice, credit is also given for assuming that reinstatement takes place after the cover is completely drained.

<i>Year</i>	<i>Loss (after reinstatement)</i>	<i>Comment</i>
467	8.1	Full reinstatement required
468	10.0	Full reinstatement required
469	1.3	Partial reinstatement required

*The above is not required to score and is for illustration only.*

Calculate for each year the amount of cover that needs to be reinstated as a result of the modelled loss events in the year. Let this be  $C_{467}$ ,  $C_{468}$  etc. Expected total losses to the contract are unchanged and the required LR is the same, so expected premium including reinstatement premium is also required to be the same.

Suppose new RoL =  $R$ .

The reinstated cover is  $C_i$  for each year  $i$ , so the reinstatement premium is 50% of  $RC_i$ .

Expected total premium =  $1 = 5R + R \sum C_i / 2n$ , where  $n$  is the number of years in the event set.

So  $R = 1 / (5 + \sum C_i / 2n)$ .

*Alternative solutions based on variants of the above are acceptable if correct and properly explained.*

*Few candidates attempted this part. Those who did attempt it tended to try to give a figure, rather than an explanation. Very few noticed that only a partial reinstatement premium would likely be payable where the original layer was only partly burnt.*

## END OF EXAMINERS' REPORT

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

5 October 2012 (pm)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all eight questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<p><i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i></p>
--

- 1** A general insurance company writes employers' liability insurance, using risk-adjusted number of staff as the exposure measure.

Discuss the factors that should be considered when determining the exposure for the purpose of pricing. [4]

- 2** (i) Describe the features of fronting arrangements. [2]

- (ii) State reasons why an insurer would use a fronting arrangement rather than underwriting a risk directly. [3]

[Total 5]

- 3** A general insurance company is building a stochastic model for the number of annual claims for a particular class of business. The following data is available:

<i>Accident Year</i>	<i>No. of claims</i>
2006	7
2007	6
2008	8
2009	5
2010	2
2011	1
Mean	4.8333
Variance	7.7667

- (i) Fit, using the method of moments, parameters for both the Poisson and the Negative Binomial distributions. [2]

- (ii) Explain which of the above two distributions is the more appropriate. [1]

- (iii) Discuss further investigations that could be conducted and additional information that may be required to improve the model. [6]

[Total 9]

4 (i) Define the term pooling. [1]

(ii) Compare pooling with conventional insurance contracts. [2]

A reinsurance company is considering renewal terms for a policy covering a yacht-owners' insurance pool.

A frequency model for the ground up claims to the pool needs to be built. Historical claim numbers and total insured values are provided.

<i>Policy Year (beginning 1 Nov)</i>	<i>Number of Claims</i>	<i>Sum Insured (£m)</i>
2007	203	25.1
2008	129	26.0
2009	179	29.8
2010	30	33.2
2011	50	25.6

The above claim numbers and sums insured are reported as at 1 August 2012.

All policy years offer coverage from 1 November to 31 October.

A marine expert states that annual sum insured inflation was 5% prior to 31 December 2009 and zero subsequently.

The table below gives development percentages for projecting claim numbers.

<i>Months since Policy Inception</i>	<i>Number of Claims Reported as a % of Ultimate</i>
60	95%
48	90%
36	70%
24	40%
12	20%

(iii) Estimate the expected number of claims for the 2012 policy year, justifying your estimate and stating any assumptions that you make. [11]  
[Total 14]

- 5 A general insurance company specialises in underwriting property and liability risks for factories. The company is assessing the renewal premium for a large chemical factory that switched its main product from Chemical Y to Chemical X two years ago.

The insurer wishes to use the factory's loss history prior to the switch, so it proposes to adjust previous loss data and use a credibility approach to determine the new risk premium. The underwriter has a prior belief that the total cost of claims per unit turnover under Chemical X will be half of that under Chemical Y.

The table below gives the turnover of the factory, which is used as the overall exposure measure, and the actual and adjusted loss data. All amounts have been adjusted onto policy year 8 terms and monetary values.

Policy Year	Turnover (£000)	Ultimate loss (£) per £000 turnover Chemical X:		
		Chemical Y: actual	prior (50% of Y)	Chemical X: actual
1	5,033	32	16	
2	5,234	34	17	
3	5,444	82	41	
4	6,123	38	19	
5	6,368	48	24	
6	6,623			35
7	6,888			38
8 (estimate)	9,000			

Let:

- “X: prior” and “X: actual” be denoted Risk 1 and Risk 2 respectively.
  - the turnover in £000 for Risk  $i$  in year  $k$  be  $V_{ik}$ .
  - the loss per £000 turnover for Risk  $i$  in year  $k$  be  $X_{ik}$ .
- (i) Specify the Bühlmann-Straub model that could be used to estimate the year 8 loss experience for the factory, stating the underlying assumptions. [5]

In the Bühlmann-Straub model:

- the long-run (hypothetical) losses per £000 turnover can be estimated as the mean of all losses per £000 turnover,  $\bar{X}$
- the expected variance of losses per £000 turnover can be estimated as

$$\hat{\phi} = \frac{\sum_{i=1}^R \sum_{k=1}^{N_i} V_{ik} (X_{ik} - \bar{X}_i)^2}{\sum_{i=1}^R (N_i - 1)}$$

- the variance of the hypothetical mean losses per £000 turnover can be estimated as

$$\frac{\sum_{i=1}^R V_i (\bar{X}_i - \bar{X})^2 - (R-1) \hat{\phi}}{V - \left(\frac{1}{V}\right) \sum_{i=1}^R V_i^2}$$

where

- $N_i$  is the number of years of data for Risk  $i$
- $R$  is the number of risks
- $V = \sum_{i=1}^R V_i = \sum_{i=1}^R \sum_{k=1}^{N_i} V_{ik}$
- $\bar{X}_i = \frac{1}{V_i} \sum_{k=1}^{N_i} V_{ik} X_{ik}$
- $\bar{X} = \frac{1}{V} \sum_{i=1}^R \sum_{k=1}^{N_i} V_{ik} X_{ik}$

The following calculations are available.

	<i>Risk 1</i>	<i>Risk 2</i>	<i>Both risks</i>
$\bar{X}_i$	23.4692	36.5294	
$\bar{X}$			27.6994
$\sum_{k=1}^{N_i} V_{ik} (X_{ik} - \bar{X}_i)^2$	2,297,024	30,388	

- (ii) Derive the estimated losses from policy year 8.

[7]

[Total 12]

**6** A general insurance company writes large commercial property insurance. The underwriter currently determines the premium by selecting an appropriate base rate for the building occupancy (for example, office or restaurant). This rate is then adjusted depending on a number of other rating factors. The base rate and adjustment factors are documented and must be followed.

- (i) List the possible rating factors for commercial property, apart from building occupancy. [4]

The management team is reviewing the current base rates and adjustment factors. An insurance broker has a database of historical claim and sum insured values for all of its clients' properties and has offered to provide information from it.

- (ii) List the data that the company would require from this database. [4]

The refined data is given to an analyst, who uses a statistical package to determine a rating structure. The underwriter states that his base rate for offices is 0.07%, whereas the corresponding rate coming out of the package is 0.05%.

- (iii) Suggest possible reasons for the difference. [7]  
[Total 15]

**7** A large Lloyd's syndicate that writes a wide variety of business has been approached by a broker representing Wheely Welaxing Wayfarers (WWW), a company specialising in the organisation of long-distance one-day cycle events.

WWW is interested in obtaining insurance to cover the situation where it is necessary to cancel an event because of adverse weather. Participants (cyclists) are required to register and pay in advance for these events. If cancellation proves necessary, WWW would refund the entry fee to each participant.

- (i) Suggest the benefits that might be provided under this insurance. [2]  
(ii) Suggest sources of data that could be used for pricing this insurance. [3]  
(iii) Describe how the syndicate could determine a price for this insurance. [12]  
(iv) Suggest ways in which the insurance policy could be structured so that claims costs can be reduced. [4]

[Total 21]



**8** A general insurance company is using a GLM to analyse claims on motor breakdown insurance. This insurance covers roadside assistance and recovery of the vehicle in the event of a breakdown.

- (i) Recommend and justify an exposure measure that would be used for motor breakdown insurance. [2]
- (ii) Describe the claims characteristics of motor breakdown insurance. [4]
- (iii) State, for both claims frequency and severity:
  - (a) the distribution that the company would be most likely to use for the GLM.
  - (b) the prior weight that it would choose. [2]

The company already has a multiplicative GLM with no interaction terms, for each of frequency and severity, using two rating factors, car age and annual mileage. It has combined these to produce a model for the claims cost per unit of exposure, with the relativities shown.

#### Relativities

<i>Car Age</i>	<i>0–1</i>	<i>2–6</i>	<i>7+</i>
<i>Relativity</i>	0.8	1.0	3.0

<i>Annual Mileage</i>	<i>0–8,000</i>	<i>8,001+</i>
<i>Relativity</i>	0.5	1.0

#### Exposure

	<i>Car Age</i>		
<i>Annual Mileage</i>	<i>0–1</i>	<i>2–6</i>	<i>7+</i>
<i>0 – 8,000</i>	900	4,700	5,273
<i>8,001 +</i>	25,450	13,025	652

- (iv) Suggest reasons why there is not much exposure data for older cars with a high annual mileage. [3]
- (v) Derive the one-way tables for each of the two rating factors, giving predicted values to two decimal places and stating any assumptions that you make. [5]
- (vi) Explain, using the results from part (v), why the GLM is a better approach to pricing than using either the car age table or the mileage table alone. [4]

[Total 20]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

September 2012 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Introduction**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

D C Bowie  
Chairman of the Board of Examiners

December 2012

## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance actuarial and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the September 2012 paper**

The level of difficulty of the paper and the general performance of candidates were similar to recent sittings. A number of well-prepared candidates scored strongly and displayed a good understanding of the subject across the whole paper. There was no significant evidence of time pressure amongst candidates around the pass-mark area.

Several candidates displayed poor handwriting at this sitting, which made it difficult for examiners to award full credit. Candidates with a disability that affects the readability of their handwriting are asked to contact the Examinations Team well in advance of the sitting for advice on what support may be available.

Question 1 asked candidates to describe how to determine a measure of exposure for pricing, but most candidates misinterpreted it as a generic question. Scores were generally very low as a result.

Apart from Question 1, Questions 6 and 7 produced the lowest ranges of scores because candidates either failed to think widely enough, or put down generic points, rather than dealing with the specifics of the question.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to include these areas in their revision.

## 1

- Historic exposure is required
- ...to assess historic claims costs.
- Actual dates on risk are needed for this
- ...and actual number of staff.
- We will need an estimate of projected number of staff over the policy period
- ...grouped by risk band, or together with a relative risk factor.
- For example:
  - Dangerous job
  - Territory worked
  - Wage band
  - Age band
  - Other sensible grouping
- The exposure calculation will depend on whether the coverage is claims made or losses occurring.

### Losses Occurring

- Prospective exposure is the estimated number of staff over the period.

### Claims Made

- The prospective exposure should consider historic staff numbers as well as estimated future numbers
- ...because new claims can arise from historic periods.
- Use a delay table to create a weighted average of them.
- Also is there a retroactive date?

### Other factors to consider

- The number of staff may change throughout the policy period
- ...or may move between risk groups.
- ... so there needs to be a way of adjusting the premium retrospectively to allow for this.
- An adjustment may be needed for part-time staff.
- Consider data quality and data adequacy

*This question was very poorly answered. The majority of candidates failed to read the question carefully, assuming that it required a repetition of bookwork on the characteristics of a good exposure measure in general. The question describes a specific class of insurance and a specific exposure measure, so the examiners were expecting points related to these. Comments on which exposure measure to use did not score.*

## 2

(i)

- A type of reinsurance arrangement
- The fronting insurer underwrites a risk
- All (or nearly all) of the risk is ceded
- The fronting insurer will receive a fee or commission

- ...to cover its expenses and profit.
- The size of the fee will take into account which party is carrying out administration and claims handling.
- In event of “reinsurer” default the liability falls upon the fronting insurer

(ii)

- Insurer may not have a licence for a particular class or territory
- ...so can achieve diversification.
- Credit rating may be inadequate to satisfy the insured's minimum requirements.
- e.g. if the insurer suffered a downgrade just before renewal.
- There may be tax advantages in issuing the policy via the fronting insurer.
- The fee payable to cover the fronting insurer's expenses may be less than the expenses that would have been incurred in writing the business directly.
- Fronting insurer may have better underwriting expertise.
- Fronting insurer may be geographically closer to the market.
- The fronting insurer may have a stronger brand in the market.
- It is a way of dipping a toe into the market without a fuller commitment.
- There may be reciprocity opportunities between the insurers.
- The fronting insurer may have more advanced or more suitable administrative/business acquisition facilities.

*Part (i) – This bookwork part was generally well-answered. Many candidates appeared to appreciate that fronting is effectively reinsurance, but failed to say so explicitly.*

*Part (ii) – This part was generally answered quite well, but candidates often focussed a little too much on tax and regulatory reasons, rather than commercial and practical considerations.*

**3** (i) Poisson :  $\lambda = 4.8333$

Negative binomial Type II:

$$\text{Mean} = k(1 - p) / p, \text{Var} = k(1 - p) / p^2$$

$$p = \text{mean} / \text{var} = 0.62231$$

$$k = \text{mean}^2 / (\text{var} - \text{mean}) = 7.96372$$

(ii) Negative Binomial as variance is much/considerably/significantly greater than mean.

(iii) Comments:

Historic exposure is needed

...and also projected future exposure.

Investigate whether the risks are similar enough to be pooled in this way.

Claim frequency needs developing to allow for reporting delays (or IBNR needs to be added).

Investigate whether the claim definition or treatment has changed over the years.

For example the treatment of zero claims.

Establish whether there has been a change in the external claims environment.

For example, litigation, regulation, behaviour, social.

Investigate what future claims trends are anticipated.

Investigate whether the policy coverage has changed.

For example, deductible levels.

Ascertain whether future coverage changes are expected.

Are more years of data available?

Is there relevant data available internally from similar products?

Is there relevant external data available?

Could consider a different method for fitting the parameters.

e.g. maximum likelihood or least squares or percentiles.

Or if a different distribution is appropriate

Carry out goodness of fit tests on the model.

Check for data errors.

Consider whether to change the weight given to older or newer years.

We would want to know what kind of business this is.

Specifically what type of distribution we would expect for this class.

Speak to relevant experts (eg underwriters) to get their opinion on the model and assumptions.

*Part (i) – Some candidates equated the first moment correctly for the Poisson distribution, but then contradicted themselves by equating the variances to give a different answer. This approach scored zero.*

*Of the two parameterisations of the negative binomial distribution, only the Type II formulation is appropriate for modelling the number of claims because it allows for the possibility of zero claims in a year. A large number of candidates used the Type I formulation and scored zero.*

*Some candidates failed to give enough significant figures in their answer to score fully.*

*Part (ii) – Better-scoring candidates observed that the variance was greater than the mean, not just different, and that it was considerably so. Some candidates made unfounded statements about independence or dispersion of claims.*

*Part (iii) – This part required a wide range of ideas for a high score. Most candidates made the key points about the need for exposure data and developed claims. However, some answers contained a lot of detail about a narrow range of ideas, and others suggested claims severity models, which were not relevant (except for nil claims). Few candidates mentioned considering the type of business or consulting with underwriters or other experts.*

- 4**
- (i) An arrangement under which the parties agree to share premiums and losses for specific insurance classes or types of cover in agreed proportions.
- (ii) Both types of arrangement employ a degree of pooling of risks.  
When insuring conventionally the insured's liability to an insurer is limited to the premium  
...whereas in a pool the liability is related to the share of the total pool's claims and expenses.  
Specific pooling is sometimes used where risks are very large.  
For example, marine liability/atomic energy  
or through associations that cater for an industry, such as P&I clubs  
Certain costs may be lower, such as marketing and brokerage.  
Members of the pool are more likely to share expertise than separate insureds.
- (iii) **Calculating the trend rate for SI**

The difficult part of the trending is from policy years 2008 and 2009. Two methods, M1 and M2, are shown here, but other methods are possible.

<i>Policy Year</i>	<i>Inception</i>	<i>months @ 5%</i>	<i>infl factor</i>	<i>trend factors</i>	
				<i>M1</i>	<i>M2 (average)</i>
<b>2008</b>	01-Nov-08	14	1.05857		1.0353
	01-Dec-08	13	1.05428		
	01-Jan-09	12	1.05000		
	01-Feb-09	11	1.04574		
	01-Mar-09	10	1.04150		
	01-Apr-09	9	1.03727		
	01-May-09	8	1.03306	1.03306	
	01-Jun-09	7	1.02887		
	01-Jul-09	6	1.02470		
	01-Aug-09	5	1.02054		
	01-Sep-09	4	1.01640		
	01-Oct-09	3	1.01227		
<b>2009</b>	01-Nov-09	2	1.00816		1.0010
	01-Dec-09	1	1.00407		
	01-Jan-10	0	1.00000		
	01-Feb-10	0	1.00000		
	01-Mar-10	0	1.00000		
	01-Apr-10	0	1.00000		
	01-May-10	0	1.00000	1.00000	
	01-Jun-10	0	1.00000		
	01-Jul-10	0	1.00000		
	01-Aug-10	0	1.00000		
	01-Sep-10	0	1.00000		
	01-Oct-10	0	1.00000		

We continue with M1.

<b><i>Policy Year</i></b>		<b><i>SI (£m)</i></b>	<b><i>Annualised SI (£m)</i></b>	<b><i>Annual Trend</i></b>	<b><i>Trend Factor</i></b>	<b><i>Trended SI</i></b>
2007	1 Nov – 1 Nov	25.1	25.1	5.0%	1.08471	27.2
2008	1 Nov – 1 Nov	26.0	26.0	3.3%	1.03306	26.9
2009	1 Nov – 1 Nov	29.8	29.8	0.0%	1.00000	29.8
2010	1 Nov – 1 Nov	33.2	33.2	0.0%	1.00000	33.2
2011	1 Nov – 1 Aug	25.6	34.1	0.0%	1.00000	34.1

Selection of 2012 trended SI: for example, 35.0

Assumptions:

- SI is written evenly throughout the policy year (or other sensible assumption, provided calculations are consistent).
- SI is at midpoint of year for inflation purposes.
- SI is a good exposure measure.
- Inflation remains at zero.

### **Developing Claims**

<i>PY</i>	<i>Month</i>	<i>% Dev</i>	
2007	57	94%	$(9*0.95+3*0.9)/12$
2008	45	85%	$(9*0.9+3*0.7)/12$
2009	33	63%	$(9*0.7+3*0.4)/12$
2010	21	35%	$(9*0.4+3*0.2)/12$
2011	9	15%	$(9*0.2)/12$

<b><i>Policy Year</i></b>	<b><i>Exposure (1)</i></b>	<b><i>Number (2)</i></b>	<b><i>% Dev (3)</i></b>	<b><i>Developed (4)=(2)/(3)</i></b>
2007	27.2	203	94%	216.5
2008	26.9	129	85%	151.8
2009	29.8	179	63%	286.4
2010	33.2	30	35%	85.7
2011	34.1	50	15%	333.3
2012	35.0			



**Selection of 2012 claims**

<i><b>Policy Year</b></i>	<i><b>Selected/ Exp. (5)</b></i>
2007	8.0
2008	5.7
2009	9.6
2010	2.6
2011	9.8
2012	

<i><b>Claims/Exp</b></i>	
simple average	7.1
weighted average	7.1
simple (07–11)	6.4
Select	6.4
2012 Exp	35.0
2012 Number	225.7

**Justification:**

- The more recent data is more representative.
- Older claims data are more certain (no IBNR).
- But exposure is less certain, due to trend assumptions.
- Generally put more weight to recent data but try to understand shift.
- Latest year is very uncertain due to large development.
- 2010 may be anomalous, so could put less weight on this.
- No explicit additional allowance for large claim/cat experience in needed.
- Completely experience-rated (past is a good guide to future).

*Part (i) – Candidates often gave quite loose definitions for this part, referring to the concept of insurers grouping large numbers of risks together to reduce the variance, rather than the specific definition for ST8.*

*Part (ii) – Many students were unclear about the differences from conventional insurance, with most only referring to profit as an issue. Stronger candidates mentioned similarities.*

*Part (iii) – This part was generally well-answered, albeit with a range of approaches. Credit was given for any sensible variants to the method shown above, particularly when the calculations were backed up by justifying assumptions. Weaker candidates used a method that contradicted information given in the question; for example, applying the development factors as if based on months since the midpoint of the policy year. Adjustments for sum insured were often over-simplified. However where the deviation from the method above was slight and the assumptions given were consistent, full credit was awarded.*

*Other common shortcomings were:*

- *Failure to interpolate the development factors to obtain the correct number of months of development.*
- *Failure to adjust the 2011 exposure to a complete year.*
- *Not giving enough points on assumptions (few students made comments on whether or not to include 2010 or 2011).*

**5** (i) Assumptions:

- There exists a latent parameter  $\theta_i$  such that:
  - $E(X_{ik} | \theta_i) = \mu(\theta_i)$  for all  $k$
  - $\text{Var}(X_{ik} | \theta_i) = \sigma^2(\theta_i) / V_{ik}$  for all  $k$
- The  $i$ th risk is described by the pair  $(\theta_i, (X_{ik})_{k \geq 1})$ , where  $(X_{ik})_{k \geq 1}$  is the sequence of claims per unit turnover observed for risk  $i$  in years  $k$ .
- The pairs  $(\theta_i, (X_{ik})_{k \geq 1})$  are mutually independent.
- The  $\theta_i$  are independent and identically distributed.
- Conditionally on  $\theta_i$ , the  $X_{ik}$ 's are independent.
- ...but not necessarily identically distributed.

Let:

- $\hat{\beta} = E(\mu(\theta_i))$  (*benchmark claims per unit turnover*)
- $\hat{\phi} = E(\sigma^2(\theta_i))$  (*expected variance of the observed claims per unit turnover*).
- $\hat{\lambda} = \text{var}(\mu(\theta_i))$  (*variance of the long-run claims per unit turnover for all risks*).

We estimate the ultimate loss per unit turnover,  $\mu(\theta_i)$  as  $z_i \bar{X}_i + (1 - z_i) \hat{\beta}$

Where  $z_i = V_i / \left( V_i + \frac{\hat{\phi}}{\hat{\lambda}} \right)$

(ii) Workings below are shown to at least 6 significant figures throughout.

$$N_1 = 5$$

$$N_2 = 2$$

$$R = 2$$

$$\hat{\phi} = (2,297,024 + 30,388) / (5 - 1 + 2 - 1)$$

$$= 465,482$$

$$V_1 = 5033 + \dots + 6368 = 28,202$$

$$V_2 = 6623 + 6888 = 13,511$$

$$V_1 (\bar{X}_1 - \bar{X})^2 = 28202 (23.4692 - 27.6994)^2 \\ = 504,663$$

$$V_2 (\bar{X}_2 - \bar{X})^2 = 13511 (36.5294 - 27.6994)^2 \\ = 1,053,438$$

$$V = 28202 + 13511 = 41,713$$

$$\hat{\lambda} = (504663 + 1053438 - 465482) / (41713 - (28202^2 + 13511^2) / 41713) \\ = 1092619 / 18269.5 \\ = 59.8056$$

$$z_2 = 13511 / (13511 + 465482 / 59.8056) \\ = 13511 / 21294.3 \\ = 0.634489$$

$$\text{Risk 2 claims per £000 turnover} \\ = (0.634489)(36.5294) + (1 - 0.634489)(27.6994) \\ = 33.3020$$

$$\text{So expected losses in 2011 for Risk 2 are } (33.3020)(9000) \\ = \text{£}299,720 \text{ (to 5sf)}$$

*Part (i) – This bookwork part was well-answered by those candidates who had learned the theory and hardly attempted by those who had not. Credit was still given where some of the subscripts were omitted.*

*Part (ii) – This part offered plenty of scope for candidates to demonstrate clear and methodical workings. Candidates who did so gained marks for the majority of their attempt, despite any numerical errors. This gave them a clear advantage over candidates who did not show sufficient workings because calculation mistakes were so common in this part. A common error was using V, rather than V<sub>2</sub>, in the calculation of z<sub>2</sub>.*

**6**

(i)

- Surveyor's report
- Type of trade or business
- Type of use of building
- Dangerous materials/processes
- Value of cash stored on premises
- Known mine workings or similar underground hazard
- Part of building unoccupied
- Age of building
- Time since last renovation
- Construction type
- Location of building/postcode
- Floor area
- Section-level limit: rebuild SI

- Section-level limit: value of contents SI
- Overall policy limit
- Excess/deductible
- Fire protection equipment e.g. sprinklers
- Security features
- Value of property
- Number of properties in the policy size – may get a size credit
- Exclusions
- EML/PML
- Period of cover
- Coverage e.g. BI included, flood, subsidence, terrorism
- Number of floors in building
- Distance from hazard, eg coast or river
- Height above sea level
- Loss history/claims experience

- (ii) Exposure/policy details
- Rating factors
  - History of changes to rating factors
  - Particularly, rating factors at time of claim
  - Policy dates/period on risk

#### Claims details

- Claim reference
- Link to policy
- Risk identifier (if the policy covers multiple properties)
- Claim status – open/closed
- Claim dates:
  - Incurred
  - Reported
  - Settled
  - of payments
- Definition of claim amount, ie ground up or after deductible
- Payment type
- e.g. indemnity, loss adjuster fee
- Amount of payment
- Estimated amount outstanding
- Date of estimate of outstanding amount
- Basis of estimate
- Recovery amount
- Policy section/type of claim
- eg stock
- Type of peril
- e.g. flood, fire

#### General

- Currency of values

(iii) **Data**

- Either set of data may be unrepresentative of the business written.
- e.g. the broker may seek out riskier business (or other example).
- The claims data underlying either rate might not have been fully developed.
- Either data set may not be large enough to give a significant result.
- The underwriter's rate may have a significant element of judgement or subjectivity.
- For a valid comparison we need to compare on a standardised coverage.
- For example flood may be in the analyst's rates, but in the underwriter rates it may be excluded and adjusted in a rating factor (or other example).
- The analyst's data might be missing catastrophe experience.
- Either set of data may be out of date.
- There may be errors in either data set.
- There may be a difference in the definition of "office".

**Method/basis**

- There may be a model or calculation error in either rate.
- Underlying assumptions may be different between the two rates.
- e.g. future claims trends, inflation (or other valid example).
- Different rating factors may have been used.
- The stated rates may be percentages of different things.
- Eg: sum insured, EML.
- Losses aren't the only contribution to the base rate.
- Differences may occur to differences in assumptions for:
  - Cost of reinsurance
  - Commission
  - Expenses
  - Cost of capital
  - Profit
  - Investment income
- The underwriter's rate may have taken into account market/competition considerations/place in underwriting cycle.
- Either rate may cross-subsidise/be cross-subsidised by another occupancy class.
- Regulations may have restricted the underwriter's rate.

*Part (i) – Very few candidates mentioned a surveyor's report, and some gave rating factors more suitable for business interruption cover (turnover), employers' liability (first aid training) or domestic house insurance (locks on windows).*

*Part (ii) – In general, this part was answered fairly well. However, many candidates revealed misconceptions about the data that insurers store on their databases, mentioning items such as inflation rates and underwriters' views. Many candidates also wasted valuable time writing exactly the same rating factors they had just given in Part (i).*

*Part (iii) – In this part, higher-scoring candidates considered a wide range of issues, rather than focusing too much on the analyst's viewpoint and possible model error. Some students*

*commented that the difference in base rates is not large enough to be significant, even though the underwriter's rate is 40% higher than the analyst's.*

- 7** (i) The company would ideally want to be put back in the same financial position as it would have been, had the tour not been cancelled.

The reinstatement of lost profits could include elements of the following:

Cost of refunding entry fees ...

... including possibly the associated postage or bank transaction costs.

Other lost income, such as:

Sponsorship from companies advertising at the event.

Commission from accommodation or sales at the event.

Legal expenses incurred in resolving disputes.

WWW may also want to be reimbursed for other outlays associated with the event for which they would be unable to get a refund upon late cancellation.

For example,

- costs of hiring buildings or other equipment (e.g. at the start or end of the event)
- costs of providing accommodation/subsistence, if included in the booking
- costs of hiring staff to run the event
- advertising
- printing

- (ii) It would collect any available data from WWW:  
such as the number of participants in similar events ...  
... or in the same event held in previous years.  
Details of dates & locations of past events.  
Number of events that have been cancelled in the past.  
Profit generated from previous tours.  
Expenditure on such events in the past.

It will also need to know the entry fee for each future event from WWW.

It could investigate if there is any relevant external data available,  
Perhaps from the broker or a reinsurer (or other feasible source)  
although this is unlikely to be the case because the risks are heterogeneous and this type of insurance is not widely written.

It may need to consult with experts (scientists, meteorological office etc.)  
because the weather will be difficult to predict.  
Or it might obtain data from a specialist data provider/bureau.

It could contact cycling organisations to see if there is any historic information on events and cancellations.

Cat models (since the risk comes from the weather).

Other weather-related insurance covers that the syndicate has written.  
Look at other event cancellations as a proxy – perhaps fun-runs?

(iii) **General points**

It may want to price each individual event separately...  
... to take account of the expected weather conditions.

or it may set a price to cover the whole season,  
up to a specified number of events and entrants.

The amount of cover will be related to the number of events.  
and the size/scale of the event i.e. the number of participants and the entry fee.

**Risk premium**

Rating factors – look at similar adverse weather policies (e.g. pluvius insurance), written by other companies or syndicates, to see what types of rating factors are used (if any).

Look at any previous claims experience from this syndicate.  
Adjust the experience to the projected period of exposure.

It will need to consider frequency and severity separately.  
...because they are influenced by different factors.

**Frequency**

It needs to consider likely weather patterns for the date(s) of the event(s), and the likelihood of the weather being severe enough to cause a problem.

In order to arrive at this, it can use a blend of relevant experience and judgement.

Relevant experience could come from weather-related data.

The judgment element may require help from relevant experts e.g. weather scientists.

This will be very difficult to predict.  
and so may be covered by a contingency margin (implicit or explicit) rather than a specific loading to the premium.

It may need to take into account the non-independence of weather events from one day to the next ...  
... for example, if a flood occurs then it might clear up in a couple of days whereas a freeze event could last for weeks.

### Severity

This will depend on the amount of cover provided.

e.g. maximum limits, excesses, exclusions (*or other example*)

- likely to be determined by the expected number of events  $\times$  average expected number of participants  $\times$  the known entry fee
- plus loadings to cover additional lost revenue
- or based on expenses incurred
- or on historic profit per event

We should allow for seasonality e.g. not as many participants during the winter months (or other sensible example)

We can ignore discounting because this is short-tailed business.

### Other loadings

Expenses

– consider the likely marginal costs associated with writing this business, especially the additional costs of consulting with weather experts for each event  
and an allowance for contribution to overheads.

Commission

– as this will be sold via the Lloyd's broker that approached us.

Profit (and contingencies)

– there is a lot of uncertainty attached to pricing this business so we might want relatively high profit loadings.

Adjust as necessary to reflect any existing relationship with the broker or insured (or cross-selling opportunity).

Competition – if there are any other insurers writing this business, or quoting for this particular contract then we would need to take account of their rates.

Reinsurance – any costs of including this class within the reinsurance cover.

Capital charge to reflect cost/availability of capital ...

... and accumulation/diversification with other UK weather risks in the portfolio e.g. property insurance.

Allow for investment income, if any.

Allow for any premium levies.

Add any premium tax.

Allow for any element of experience rating in the policy.

Allow for an adjustment premium to reflect a different number of entrants from that assumed.



(iv)

- Apply an excess
- ...to reduce all claims
- ...and eliminate small claims
- Apply an aggregate deductible if cover is multi-event.
- Impose an upper limit on the cover
- ...to reduce large claims
- ...either per event or overall
- Require WWW to participate in the risk e.g. by making them cover a % of the cost (participation clause)
- Or introduce an element of experience rating
- ...to ensure that WWW doesn't cancel events unnecessarily (/reduce moral hazard).
- Require WWW to have an adequate level of contingency planning e.g. an alternative route in case a specific road is closed due to flooding.
- Require WWW to limit losses by using contract wording with entrants & suppliers.
- Require WWW to insure all events rather than selecting certain ones, to minimise the claims costs per tour and avoid anti-selection.
- Be very clear on the definition of how intense a weather event has to be before the insurance will become payable.
- e.g. at least 2 inches of rain in the preceding 24 hours along any part of the course.
- Require WWW to attempt to reschedule events.
- Require WWW to vet entrants' claims for possible fraud.
- Exclude some perils or risks.
- Restrict location (e.g. not in very wet or snowy places).
- Restrict the dates of events covered (eg midwinter).

*Part (i) – Most candidates were able to generate the main points. However, many suggested that the product would cover the cost of rescheduling events and physical damage done to equipment or property by bad weather, neither of which is appropriate.*

*Part (ii) – This part was answered well, but very few candidates mentioned getting any data from the insured.*

*Part (iii) – Candidates tended to produce generic answers, rather than attempting to deal with the specific situation. The better answers considered the entire pricing basis, and for claims experience how the frequency (likelihood) and severity of claims could be more accurately quantified in the face of considerable uncertainty. In contrast, many candidates provided excessive detail on minor aspects of the solution, such as discussing in depth the types of model that would be used for claims, such as GLMs. The main problem here was that many candidates appeared to think that the risk could be largely experience rated, or that there was plenty of stable historical data available, both of which are very unlikely.*

*Part (iv) – This part was generally answered well, with most candidates giving a good range of points.*

**8**

- (i) Vehicle-years or policy years.  
Level of risk is reasonably proportional to it  
Easy to quantify/known at the start of the policy  
Objective/can't be manipulated  
Easily verified from policy records  
Acceptable to policyholder, legislators, regulators.

*Alternative answer (not additional)*

Vehicle-miles  
Level of risk is reasonably proportional to it  
Can be verified, but needs an independent party or reliable equipment  
Acceptable to policyholder, legislators, regulators.

- (ii) Frequency: relatively high ...  
... although there may be limits on how many callouts are allowed in any year.

Seasonality would be expected  
(more breakdowns in extreme temperatures or at very busy times on the roads)

Moral hazard element because insured may try to buy cover knowing the vehicle is in poor condition.  
Moral hazard element because the insured may fail to minimise losses once the insurance is in place (eg running the fuel tank very low)

Geographical variations from differences in traffic/road conditions.

Accumulations possible from weather or other events.  
There may be trends over time, as vehicle types or usage patterns change.

Reporting delays – very short.  
Breakdowns are generally reported very quickly because losses usually arise from incidents that are observed at the time.

Settlement delays – (very) short.  
The value of the loss is usually straightforward to establish and claims are usually dealt with very quickly.  
may be exceptions, eg dispute over coverage if breakdown occurs near home.

Claims amounts – relatively low compared with most other classes.  
Amounts not very volatile  
Inflation will be linked to mechanic's wages.  
also fuel costs and value of cars and car parts.  
There may be nil claims for events not covered by the policy (eg wilful damage).

Some currency effects where foreign travel is involved.

- (iii) (a) Frequency – Poisson  
Severity – Gamma  
*Marks were given for other sensible frequency and severity distributions e.g. negative binomial, lognormal, Pareto, Weibull.*
- (b) *Take care that the correct terminology is used here*  
Frequency – number of exposures (*credit if actual exposure measure given*)  
Severity – number of claims
- (iv) It might be the case that older cars do fewer miles each year so there will not be as many cars in this combination in the overall population.

Existing / previous breakdown cover might have excluded old or high mileage cars.

Or the rates may have penalised older cars with higher mileage (compared to the competition) so we may have written fewer policies here.

Either because the rates are high for older cars or for high mileage cars or for the combination.

The breakdown cover might have previously been marketed mainly at newer cars.

e.g. sold by motor manufacturers at the point of sale of a new car.

There may be fewer older cars in the overall population.

e.g. due to government incentives to buy new cars.

If breakdown insurance is written only as an add-on to motor insurance and the underlying motor rates are uncompetitive for this combination (e.g. because it's not the part of the market we're targeting) then there won't be many cars in this combination that are eligible for the breakdown insurance.

There could be an error in the data e.g. if it hasn't picked up all the cells.

It may be the case that people with older cars more likely to understate the mileage.

- (v) Assume that the relativities given are exact i.e. there is no random variation and/or they are truly representative of the risk.

<i>Car Age</i>	<i>Mileage</i>	<i>Exposure</i>	<i>Predicted Value</i>	<i>Total Response</i>
0 – 1	0 – 8,000	900	0.40	360
0 – 1	8,001+	25,450	0.80	20,360
2 – 6	0 – 8,000	4,700	0.50	2,350
2 – 6	8,001+	13,025	1.00	13,025
7 +	0 – 8,000	5,273	1.50	7909.5
7 +	8,001+	652	3.00	1956

### One-Way Tables

Car Age	Total Exposure	Total Response	Predicted Value
0 – 1	26,350	20,720	0.79
2 – 6	17,725	15,375	0.87
7 +	5,925	9,865.5	1.67

Mileage	Total Exposure	Total Response	Predicted Value
0 – 8,000	10,873	10,619.5	0.98
8,001+	39,127	35,341	0.90

(vi) **One-way table for Car Age**

The ratio of predicted values (re-basing 2 – 6 to be 1.0) is: 0.91 : 1 : 1.92  
This understates the true relativities of 0.8 : 1 : 3.0

because the good experience for young cars (0 – 1) is masked by the higher mileage done by these cars

(equivalently) because the poor experience for older (7+) cars is masked by the lower mileage done by them.

### One-way table for Mileage

The ratio of predicted values (re-basing 8,001+ to be 1.0) is 1.09 : 1

This gives very misleading results compared with the true relativity of 0.5:1 : 1

because most of the vehicles with low mileage are older (i.e. the good experience for low mileage is masked by the older age of these vehicles)

(equivalently) because the vehicles with high mileage tend to be newer (i.e. the worse experience for high mileage vehicles is masked by the fact that this mostly relates to new cars).

### General

A GLM will unpick these relationships and therefore produce estimates of the true values of the relativities.

The GLM can also be extended by adding an interaction term if this is significant.

*Part (i) – This part was generally answered well, although some candidates suggested an exposure measure based on the age of vehicles, which would not be appropriate.*

*Part (ii) – This part was generally answered well, but some students used imprecise terms, such as “claims are short-tailed” or “claims are positively skewed”, which could not be given credit.*

*Part (iii) – This part prompted a range of answers, many of which showed a lack of understanding. Answers for (a) were generally correct, but some candidates suggested the Normal distribution for severity, even though negative claim amounts are unlikely. Many candidates appeared not to understand the meaning of “prior weight” in (b).*

*Part (iv) – This part was answered quite well, particularly where candidates came up with a range of different points. Candidates scored less well where they focused on reasons why there would be few old cars covering high mileages on the roads, or reasons why there would not be many old cars on the roads (ignoring the mileage aspect of the question).*

*Part (v) – Answers to this part were very variable. A large number of candidates were unable to identify the correct calculation to perform, but those who found the right method had little difficulty in scoring full marks. Some candidates lost marks by not performing intermediate calculations with sufficient precision for an answer to two decimal places, or not showing workings clearly enough.*

*Part (vi) – Most candidates were able to make relevant points in this part, but answers were generally not very thorough. High-scoring candidates justified their answers with evidence from Part (v), rather than relying on generic statements about the benefit of GLMs. Full credit was given for observations that were consistent with the results from Part (v), even where those results were calculated incorrectly.*

## **END OF EXAMINERS' REPORT**

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

16 April 2013 (am)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 10 questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i>
---

- 1** A general insurance company uses exposure curves to estimate losses on commercial property risks.

Suppose  $Y$  is a random variable representing the size of loss as a proportion of the total sum insured ( $M$ ). The exposure curve is defined as:

$G(x) = LEV(x) / E[Y]$ , for  $x > 0$ , where  $LEV(x)$  is the limited expected value function:

$$LEV(x) = \int_0^x (1 - F(y))dy,$$

where  $F(y)$  is the cumulative density function of  $Y$ .

The following table gives values from an exposure curve that is used to price a commercial property risk with a total value of \$1m.

$Y$	$G(y)$
2.5%	7.0%
5.0%	14.0%
7.5%	20.0%
10.0%	27.0%
25.0%	56.0%
50.0%	84.0%
75.0%	97.0%

Using this curve, the expected loss to a policy covering the layer \$475k in excess of \$25k has already been calculated as \$10,000.

Calculate the expected loss to the layer \$700k in excess of \$50k. [3]

- 2** A general insurance company is considering the introduction of an “early bird” offer for renewals on its existing book of personal lines policies. Renewal is not automatic and the policy will lapse if no instruction to renew is given. Customers who give instruction to renew at least a month before the renewal date would receive a discount from the standard renewal price. The company has no experience of running such an offer.

The company wishes to determine the level of discount to be offered in order to increase the profitability of the book by a target amount over the period of the offer.

Outline the process that the company should follow. [7]

- 3** The total claim amount payable,  $S$ , during a specified period in respect of a block of policies may be expressed as

$$S = X_1 + X_2 \dots + X_N,$$

where  $X_i$  is the claim amount payable during the period in respect of the  $i$ -th claim and  $N$  is the (random) number of claims during the period.

A general insurance company believes that the number of claims has a Poisson distribution with mean  $\mu$  and that the individual claim amounts follow a gamma distribution with parameters  $\alpha$  and  $\lambda$ .

- (i) Derive expressions for the mean and variance of  $S$  in terms of  $\mu$ ,  $\alpha$  and  $\lambda$ . [2]

The insurer decides to use stochastic simulation to approximate the aggregate claims distribution for  $S$ .

- (ii) Outline:

- (a) the benefits of simulation, and
- (b) how the simulation would be carried out

[4]

[Total 6]

- 4** A general insurance company is considering the type of pricing model to build for the following insurance propositions:

- (a) A professional indemnity policy for a very recently established firm of architects. The insurer has other large, well-established books of similar business, for which five years of detailed data on past claims experience and exposure are readily available.
- (b) A large fleet of chauffeur-driven limousines, for which exposures and claim amounts are aggregated and reported to the insurer in summary form each calendar month.
- (c) An inwards reinsurance treaty covering a book of employers' liability policies that has risk-level and aggregate-level deductibles and limits, and a profit commission element.

Discuss, for each of the propositions, whether a frequency/severity or burning cost method would be more appropriate for the purpose of pricing. [8]



**5** The pricing team of a general insurance company is about to conduct an exercise to investigate the profitability of recently underwritten motor business. As the claims experience will not yet be mature, it has decided to make use of the reported claim amount recorded on its claims system to give an initial estimate of profitability. The reported claim amount consists of paid claims and case reserves.

- (i) Suggest ways in which the company may have determined the level of case reserves to record on its claims system, other than in relation to reopened claims. [4]

During the exercise, it transpires that movements for reopened claims are missing from the data extract, the effect of which is that the latest available claim amount is the amount as at the point of closure.

- (ii) Suggest the reasons that a claim may need to be reopened. [2]

- (iii) Discuss the impact of using the incomplete dataset for pricing. [4]  
[Total 10]

**6** A general insurance company writes property business in three divisions:

- household
- small commercial
- large commercial

The company has just purchased outwards catastrophe reinsurance coverage with an excess of £20m. It gives coverage for all three divisions.

- (i) Suggest the perils that the catastrophe reinsurance is most likely to cover. [3]

The company wishes to allocate the costs of this layer to each of the three divisions for the purpose of pricing. The underwriter for large commercial properties states that his division should not be allocated any catastrophe reinsurance costs because his maximum limit per claim is £5m, which is well below the £20m excess.

- (ii) Comment on the underwriter's opinion. [2]

- (iii) Describe how the catastrophe reinsurance cost could be allocated between the three divisions. [4]  
[Total 9]

- 7** A general insurance company is comparing the Classical and Bayesian credibility models for a rating exercise for a particular class of business.

The basic formula for calculating credibility weighted estimates is:

$$Z \times (\text{Statistic from Observed Data}) + (1 - Z) \times (\text{Ancillary Statistic}),$$

where  $0 \leq Z \leq 1$ .

The Bayesian credibility factor under consideration is:

$$Z_B = \frac{n}{n + k}$$

where  $n$  is the number of claims in the class of business in question, and  $k > 0$ .

Suppose that  $n_F$  is the number of claims required for full credibility under the Classical model.

- (i) Show that  $k = n_F (n / n_F)^{1/2} [1 - (n / n_F)^{1/2}]$  when the two different credibility curves cross. [3]
- (ii) Hence, derive a relationship between  $n_F$  and  $k$  that allows the two credibility curves to cross in the middle of the possible range of credibility. [3]

The company is considering the ancillary statistic that will receive the complement of credibility, i.e.  $(1 - Z)$ , for the rating exercise.

- (iii) Discuss the issues that the company should consider when selecting the ancillary statistic. [6]
- [Total 12]

- 8** (i) Describe the cover provided by liability insurance. [3]

A large construction company is reviewing its liability insurance requirements.

- (ii) Suggest, with reasons, the types of liability insurance that the construction company should obtain. [8]

The construction company is about to commence a project to build a new hotel and is seeking property cover for the duration of the project.

- (iii) Explain:
  - (a) why the risk profile for the property cover might not be uniform throughout the lifetime of the policy, and
  - (b) how this might be included in the rating process.

[4]  
[Total 15]

- 9 A general insurance company writes professional indemnity insurance for solicitors on a losses-occurring basis.

The company insures a large law firm whose policy is due for renewal soon.

The following data has been provided:

<i>Policy Year</i>	<i>Notified Claims (£000)</i>	<i>Policy Excess (£000)</i>	<i>Limit per Claim (£000)</i>
2008	764	50	150
2009	638	50	150
2010	318	25	100
2011	402	25	100
2012	140	25	100
2013	See below	50	100

<i>Calendar Year</i>	<i>Average Number of Solicitors in Year</i>
2008	210
2009	208
2010	215
2011	214
2012	210
2013	213

The following information has been supplied for the data above:

- All policy years run from 1 July to 30 June.
- There is no aggregate limit on the total amount of claims in a policy year.
- Notified claims are as at 31 March 2013.

The following assumptions apply:

- Claims severity inflation is +5% per year.
- Claims frequency inflation is +2% per year.
- Claims development factors are as in the following table:

<i>Policy Year</i>	<i>Claims Notified as % of Ultimate (as at 31 March 2013)</i>
2008	90%
2009	80%
2010	65%
2011	45%
2012	15%

- The following increased limit factors are applicable to all policy years without the need for adjustments for severity trends:

<i>Limit (£000)</i>	<i>ILF</i>
-	-
25	0.50
50	0.70
100	1.00
125	1.15
150	1.25
200	1.40

Estimate the loss cost for the 2013 policy, showing all workings and justifying any further assumptions that you make. [13]

- 10** A motorist, who has recently passed her driving test and purchased her first car, has obtained quotes for motor insurance that range from about £600 to over £9,000. She is puzzled about how it can be possible for insurers to provide such different quotes for exactly the same level of cover.

Explain, with examples, the most likely reasons for the wide range of quoted amounts. Your answer should cover the following aspects:

- fundamental uncertainty in the rating basis
- data
- modelling techniques
- adjustments to historic data in the rating basis
- market considerations

[17]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

April 2013 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Introduction**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie  
Chairman of the Board of Examiners

July 2013

## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance actuarial and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the April 2013 paper**

The level of difficulty of the paper and the general performance of candidates were similar to recent sittings. There was some evidence of time pressure amongst candidates around the pass-mark area. Of those candidates who failed narrowly, a significant number appeared to have spent too long on the questions that they attempted at the start of the examination, which meant that their later answers were rushed and failed to score well.

At least eight candidates displayed poor handwriting at this sitting, which made it difficult for the examiners to be sure that they had awarded full credit for the answers. Candidates who struggle with the legibility of their handwriting are asked to contact the Examinations Team well in advance of the sitting for advice on what support may be available.

Question 2 asked candidates to describe the process of determining the level of discount to give customers for renewing early. Most candidates struggled with this question, showing a lack of commercial awareness. Scores were generally very low as a result. Question 9 also produced generally low scores because candidates often had difficulties with the numerical content, and few gave enough valid assumptions.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to concentrate their revision in these areas.

# 1

FV	1,000,000	
<b>Layer 1 – \$475k xs \$25k</b>		
	Amount	%
Lower	25,000	2.5%
Upper	500,000	50.0%
G(Layer 1)	84.0%–7.0%	77.0%
<b>Layer 2 – \$700k xs \$50k</b>		
	Amount	%
Lower	50,000	5.0%
Upper	750,000	75.0%
G(Layer 2)	97.0%–14.0%	83.0%
EL(Layer 1)		10,000.00
EL(Full Value)	10000/77%	12,987.01
EL(Layer 2)	12,987*83%	10,779.22

*Full credit was given for combining parts of the above into fewer steps, provided that workings were clear and correct. Very few candidates had any problems with this question, except for a few numerical slips.*

## 2 Overall approach

- To propose the theoretical level of discount, it should compare the expected profit streams of the business with and without the discount...
- ... and then set the level of discount to achieve the profit hurdle.
- Several options and scenarios might be presented.
- As well as the theoretical model, the company should consider practical matters, such as:
  - how best to present the discount so that it appears sensible (e.g. applying rounding)
  - whether the discount will be appealing enough to the customer to justify the promotion

- consider whether a sliding scale, dependent upon how early they renew, would be appropriate
- whether there are any regulatory, legal or customer treatment issues with the terms or level of the discount
- in particular, whether the company can change the “normal” price from its current level at the same time as starting the offer
- documentation should be produced

#### Modelling the discount

- Segment by class of business, distribution channel, etc.
- Investigate the following factors to assess how much they are likely to be affected by the introduction of a discount...
- ...and how much they would vary as a result of different levels of discount:
  - Probability of early renewal (or volume of renewals)
  - Profitability of policies that renew
  - Profitability could be influenced by:
    - Types of policy renewing (ie, change in mix and policy size)
    - Claims experience
    - Mid-term cancellation rate
    - Administrative expenses incurred at renewal
    - How to treat claims occurring between time of invite and policy anniversary, in cases where the date of invite is earlier than usual
    - impact upon new business - save money on marketing and commission?
- Quantify the cost of any additional system changes
- Allow for competitor reaction/levels of discount
- Decide on the pricing strategy for future years after the discount is given
- ...because this will affect the customer lifetime value.
- E.g., will the discount persist or be removed?



- Ensure that the loadings for other items in the rates (e.g. cost of capital, reinsurance, investment income) are updated.
- The above elements are likely to be difficult to judge because the company has no previous experience
- ...so it is important to assess the sensitivity of the modelled discount to the key assumptions.
- and may want to include additional prudence for uncertainty
- Some market research or consultation with experts may be helpful here.

*Note that a stochastic model is not appropriate – this would be an over-elaborate approach for the circumstances, and it would be likely that there would be a lack of data.*

*This question was very poorly answered. Most gave generic answers on how to set up a profit testing model. Many candidates dived straight into data collection or constructing a GLM without setting out the structure of the exercise, and consequently failed to score well.*

*Attempting to use external data was a common theme in answers, but this showed a lack of understanding of the type of data that is likely to be available in a competitive market.*

*Many candidates suggested a pilot exercise, which is a perfectly valid method of model validation and evolution, but this was slightly outside the scope of the question.*

*It was disappointing that hardly any candidates considered the more practical aspects of introducing a discount.*

**3** (i)  $E(S) = E(N)E(X)$   
 $\text{Var}(S) = E(N)\text{Var}(X) + \text{Var}(N)[E(X)]^2$   
 $E(N) = \mu$   
 $\text{Var}(N) = \mu$   
 $E(X) = \alpha/\lambda$   
 $\text{Var}(X) = \alpha/\lambda^2$

Therefore:

$$E(S) = \alpha\mu/\lambda$$
$$\text{Var}(S) = \alpha\mu/\lambda^2 + \mu\alpha^2/\lambda^2 = \alpha\mu(1 + \alpha)/\lambda^2$$

- (ii) (a) Can be used as a check on the distributional (theoretical approach).

It can be used to estimate probabilities without making distributional (Normal/Gamma) approximations.

Can be simpler to apply than an analytical approach

Deals more easily with complex policy features, such as individual and aggregate deductibles and limits.

Can accommodate reinsurance recoveries more easily

- (b) Simulate the number of claims  $n$  from the distribution describing the number of claims (e.g. Poisson)

Sample  $n$  times from the claim size distribution (e.g. Gamma) to obtain values for  $X_1, \dots, X_n$

It may be necessary to apply individual limits and deductibles to the  $X_i$

Sum the  $X_i$

It may be necessary to apply aggregate limits and deductibles

Repeat the above a large number of times (e.g. over 100,000)

*Part (i) – this was straightforward and caused few problems.*

*Part (ii) - most candidates misinterpreted (a) as a question about the advantages of a probabilistic model over a deterministic one, which rendered nearly all of their points invalid. For example, most candidates commented that the output of a simulation is a distribution of possible results, which is correct but did not score, because this is also the output of an analytical approach. For (b), the examiners were looking for a clear, precise, step-by-step description, which most candidates were able to provide. The most common problem was forgetting to apply deductibles and limits.*

- 4** (a) Frequency/severity is likely to be more appropriate.

Even though there is no past data for the new policy, the frequency & severity distributions can be modelled from similar books.

Some adjustments would probably be needed to make the data suitable for the new book, but this should not be a major problem.

If substantial data is available, it will be more accurate to use frequency/severity models.

Reasons:

They reflect more accurately the underlying process of generating losses, each with an independent ultimate value.

It is easier to isolate the drivers of differences in aggregate losses.

They help to identify trends in loss experience over time.

If expenses are attributable to frequency or severity, they can be loaded into prices more accurately.

- (b) Burning cost is likely to be most appropriate.

The aggregated nature of the data will probably make a frequency/severity approach inappropriately complex.

The book is quite specialist and large, so is likely to be heavily experience-rated, which makes it difficult to build a frequency/severity model from similar books.

- (c) Frequency/severity likely to be more appropriate if there is sufficiently detailed data

The aggregate deductibles and complex structures in the treaty are very difficult to handle analytically...

...therefore a stochastic simulation approach should be used.

Risk-level deductibles and limits are easiest to handle if the severity distribution is modelled separately.

It may be necessary to model attritional and large losses separately, which is easier in a frequency/severity model.

An advantage of fitting/simulating a distribution is that it will produce some variance of results in order to trigger payment of the profit commission, which would not be possible with the burning cost approach.

Burning cost would be an alternative if there is insufficient historical data for frequency/severity...

... and provided that the past experience is stable enough to give a good indicator of the future

*Candidates in general made a good attempt at this question; however, several candidates did not give a definitive choice, instead giving the pros and cons of each, thereby failing to pick up some of the available marks.*

*For part (a) many failed to express why the frequency/severity approach is useful. Candidates tended to say that frequency/severity was advisable due to the available data, but did not say why.*

*In (b), many candidates stated that frequency/severity was impossible, which is not strictly true. It would simply need more assumptions to be made that are not supported by the available data.*

*In (c), many candidates stated that frequency/severity with stochastic simulation was the best approach, but failed to justify each aspect properly. Very few gave a coherent consideration*

*of modelling the profit share. Candidates frequently spent time discussing poor data quality because it is a reinsurance contract, but failed to address the special features of the contract stated in the question.*

- 5** (i) Initial estimate, or gut feel, of claim handler at time of notification  
...then updated subsequently...  
...either when a payment is made, or periodically, or when additional information is received
- Standard, or default, estimate...
- ...set by reference to the type of claim
- Algorithm, using statistical methods to estimate the value based upon certain risk and/or claim characteristics
- As advised by the lead insurer, in the case of co-insurance...
- ...(This would not be common for a motor insurer)
- Using estimates/invoices from repairers
- Estimates from loss adjusters or specialist claim assessors
- Bulk estimates for a group of claims, where claims handling is delegated to an external company and aggregated amounts are input to the system
- Aggregating estimates across multiple heads of damage (e.g. own damage, third party property damage, third party injury, etc.) and entering this onto the system, perhaps where only one claim amount field is available
- (ii) A further payment comes to light for costs incurred by the insurer in investigating and settling the claim
- The insurer has made a recovery against a third party involved
- Further development of the existing claim
- An error was made in closing the claim originally, or was closed by an automatic process
- The insurer may receive a further claim from a third party for which the insured was liable
- There is a dispute or complaint from the policyholder.
- The insurer enters into litigation concerning the claim.

A retrospective requirement to reopen claims, e.g. as a result of a legal or regulatory ruling

- (iii) Cost of risk may be distorted, due to errors in the apparent claims experience and its trends

The proportion of nil claims could be misstated

It may be the case that certain claim types have larger discrepancies than others...

...e.g. bodily injury or other liability

This could lead to distortion of the true distribution of claim costs between risk groups...

...e.g. young drivers appearing lower risk than they actually are

This could lead to incorrect differentials between prices across risk groups

It might also affect marketing strategies if certain risk groups appeared to have different claims costs from actuals

If the insurer adopts a deficient set of rates as a result of faulty data, it might: suffer underwriting losses if rates are too low

suffer loss of market share if rates are too high

attract undesirable risks, causing deterioration in underwriting experience, if rates for such risks are too low

impact reinsurance or capital loadings

trigger a rate review, when one is not required (or vice versa)

affect development patterns

*Part (i) – Some candidates went into the detail of BF/Chain Ladder methods without just considering the basic approaches that are practically applied. It was very common for candidates to misunderstand the term case reserves and give an answer more appropriate to a bulk reserving exercise. Many candidates suggested asking the underwriter, but the question relates to personal lines motor insurance and this suggestion was not considered valid.*

*Part (ii) – This was well answered in general, but many just gave two or three points and, therefore, failed to pick up the full marks.*

*Part (iii) – Most candidates failed to discuss the issue of incorrect differentials across risk groups. Hardly any candidates mentioned that some types of claims could be more subject to distortion than others.*

- 6** (i) Hurricane/windstorm/Cyclone/typhoon  
Earthquake  
Tsunami  
Flood

Hail  
Volcanic eruption  
Terrorism (often excluded, depending upon territory)  
Riot

Industrial accident  
Fire/conflagration  
Freeze

Subsidence  
Lightning  
Explosion  
Tornado  
Snow

- (ii) The coverage is for an accumulation of losses, not for individual losses

The underwriter's portfolio will most likely have multiple properties that may be affected by the same catastrophe event

Even if the underwriter's portfolio is so diverse that the same event cannot affect more than one property, then there will still most likely be a clash with one of the other divisions.

Claims from the same event but different divisions will still be grouped together for reinsurance recoveries, so their portfolios should still make a contribution to the cost of reinsurance.

- (iii) The exercise is effectively to price the outwards layer, and calculate the contribution from each of the 3 classes.

Starting point is using a catastrophe model for the company's exposures

The financial analysis module will allow us to model the cat layer. This will give the expected recoveries under the policy.

Summing all of the expected recoveries will give the expected recoveries for each division

Then allocate cost in proportion to the expected recoveries

A more sophisticated approach may involve looking at the volatility of recoveries e.g. looking at return periods

For instance a division that makes a volatile use of the layer would have a larger charge than a less volatile one even if it had the same expected recoveries.

In addition we could look at how the 3 classes correlate together in the outwards layer

If two classes correlate together more than the other they should have a higher reinsurance charge

May also want to consider uncertainties in the exposure data. May be greater for some divisions than for others

There are other simpler approaches which may not involve catastrophe modelling e.g.:

Pro rata costs by sum insured or by premium

Pro rata costs by total PML

Stress testing the portfolio on individual loss events

These could be used in particular for non-natural catastrophes, such as terrorism

*Part (i) – This section was well attempted by almost all candidates.*

*Part (ii) – This was quite well attempted by most. However, many failed to consider that the accumulation could occur between the commercial division and the other divisions in the company. The better candidates spotted that accumulations could apply across divisions from the same event.*

*Part (iii) – This was quite poorly answered, with most candidates only getting a few basic points. The better candidates considered situations in which a simple allocation in proportion to expected recoveries might be appropriate – e.g. correlation between divisions, and volatility within each division.*

**7** (i) Under the Classical model,

$$Z_C = \begin{cases} (n / n_F)^{1/2} & 0 \leq n < n_F \\ 1 & n \geq n_F \end{cases}$$

We can ignore the case  $Z_C = 1$  because this would require  $k = 0$ .

The two definitions of credibility are equal when:

$$n / (n + k) = (n/n_F)^{1/2}$$

so:

$$k = n * (n/n_F)^{-1/2} - n$$

Multiply both terms on RHS by  $n_F / n_F$ :

$$k = n_F * (n/n_F) * (n/n_F)^{-1/2} - n_F * (n/n_F)$$

$$k = n_F * (n/n_F)^{1/2} - n_F * (n/n_F)^{1/2} * (n/n_F)^{1/2}$$

$$k = n_F (n/n_F)^{1/2} [1 - (n/n_F)^{1/2}]$$

(ii) Since  $Z_C = Z_B = Z$

$$\text{and } Z_C = (n/n_F)^{1/2}$$

$$\text{we can write } k = n_F \cdot Z(1 - Z)$$

$Z$  must lie between 0 and 1 so the middle of the range is where  $Z = 0.5$ .

Substituting  $Z = 0.5$  into the equation gives:

$$K = n_F (0.5 * 0.5)$$

$$\text{So } n_F = 4k$$

(iii) **Practical Issues:**

The statistic must be easily available,  
and up to date

The statistic must be easy to compute  
and therefore easier to explain to management and customers  
and less likely to result in errors  
and cheap to produce

**Competitive Market Issues:**

The statistic should help make the overall rate:

As unbiased as possible  
(not too high or too low over a large number of loss cost estimates)

As accurate as possible  
(with as low an error variance as possible around the future losses being estimated)



**Regulatory Issues:**

- The statistic should have a logical relationship to the loss costs of the class or individual being rated in order to help mitigate regulatory concerns and/or to make it easier to explain a high rate in light of the related costs.

**Statistical Issues:**

- The statistic should be statistically independent from the base statistic so that the resulting rate is more accurate.

*Part (i) – This was, in general, well answered by most. Very few candidates considered the case  $Z=1$ .*

*Part (ii) – Many candidates did not attempt this part, and those who did often failed to give clear reasoning for their answer.*

*Part (iii) – With it being a bookwork-type question, some candidates did very well on this section. However, many went down the wrong path and failed to give the detail required.*

- 8** (i) Liability insurance provides indemnity where the insured, owing to some form of tort (private or civil wrong, such as negligence), is legally liable to pay compensation to a third party.

Cover can be on a claims-made or losses-occurring basis (or equivalently, a limit on the time period during which a claim may be accepted).

Any legal expenses relating to such liability are usually also covered.

There may be exclusions to cover for certain causes (e.g. an illegal act of negligence).

The extent of any legal liability may depend on the prevailing legislation.

There may be a limit to the amount of cover available.

And will usually involve an excess.

- (ii) **Employers' liability**

The construction process is likely to involve hazardous materials or working conditions.

EL cover indemnifies the company against legal liability to compensate an employee or his or her estate

for bodily injury, disease or death

and loss of, or damage to, employees' property

owing to negligence of the employer, or fellow employees, in the course of employment.

In many countries it is also a legal requirement.

**Directors' and officers' liability**

The company is likely to purchase D&O insurance on behalf of its Directors to indemnify them against legal liability to compensate third parties owing to any wrongful act

e.g. allowing false financial statements to be published

allowing the company to continue operating when it should have been declared insolvent

any act resulting in the insured being declared unfit for his or her role.

**Motor third-party liability**

The company will own various motor vehicles, e.g. for transporting materials  
MTPL covers the driver's legal liability to pay compensation to a third party for personal injury

or damage to their property

In many countries the cover is compulsory.

Marine or aviation liability cover might also be required for a large company if it owns these types of vessel.

**Public liability**

The company will want to be indemnified against legal liability to pay compensation to a third party

such as visitors to the site and owners of neighbouring properties

other than those liabilities covered by other liability insurance.

May be a compulsory cover in some territories

**Environmental liability**

The company should indemnify itself against the legal liability to compensate third parties

as a result of unintentional pollution for which they are deemed responsible.

This would also cover the costs of cleaning up the pollution

and may also cover any regulatory fines.

**Professional indemnity**

The company may employ surveyors and architects and will want to indemnify itself against legal liability for losses resulting from incorrect advice, an error in plans (or other suitable example).

It may also want to buy insurance against faulty or unsatisfactory workmanship in the construction.

- (iii) (a) The sum insured increases as the project nears completion – tending to the rebuild value.

Or the sum insured may vary if parts of the build become occupied and no longer covered under the construction company's insurance.

The risk to each peril covered varies differently over the duration of the build....

... e.g., for storm, losses would be relatively low at the start of the project

... whilst for theft of raw materials, the risk will rise and fall at different stages (or other suitable examples).

Inflation over the length of the contract is likely to affect the cost of claims.

Seasonality or economic cycles may affect the intensity of risk over the period.

The sum insured may also change following revised plans from the architect...

... or alterations to the build may be required to meet changing buildings regulations.

- (b) If a flat exposure measure is used over the whole period, we would apply a percentage load to it that varies over time according to the risk profile.

Or use an exposure measure that varies over the term of the contract.

This would allow a deposit premium to be determined.

Over the duration of the contract, the assumptions could be updated and an adjustment premium derived.

It may be useful to split the premium by the different types of cover, to allow for the variation in different types of risk more accurately.

*Part (i) – Many gave the correct definition of what liability insurance is, but many failed to gain the other marks for extra detail in terms of limits/excesses/exclusions etc. At the same time, many were unable to give a precise definition – for example, implying that insurance indemnifies or covers third parties. Candidates tended to concentrate on the legal liability for compensation, but missed several other points relating to the cover. Given the 3 marks available, this was surprising. Many candidates mentioned claims characteristics, sometimes at length, which was not required.*

*Part (ii) – Most candidates gave a good broad range of likely liability insurance requirements for this company. However, many candidates failed to define what exactly each individual type of liability insurance covers – who the insured party is and what they are covered for. Candidates talked about bodily injury, disease and death, but fewer mentioned other types of loss sustained by third parties, such as property damage. Few said that the pollution should be unintentional to be covered.*

*Part (iii) – In (a) most candidates explained that the risk will increase over time, but did not consider the other possibilities – change in risk to each peril etc. Most candidates described increases in the value of the partially-completed property. However, those who described the origins of variation of risk in terms of materials and perils scored much higher. Many talked about the risk to the staff, but this part of the question related to property cover for the insured. Part (b) was particularly poorly answered, despite being quite simple.*

**9** Project number of solicitors in calendar year 2014

No clear trend in growth over time (perhaps slight recent increase).

Sensible estimate based on historic numbers (i.e. between 211 and 215)

213 is selected below.

Convert number of solicitors from calendar years to policy years

Assume linear interpolation is appropriate

...from calendar year midpoint to policy year midpoint

i.e. 1 Jul to 1 Jan

<i>Policy Year</i>	<i>Number of Solicitors</i>
2008	209.0
2009	211.5
2010	214.5
2011	212.0
2012	211.5
2013	213.0

Adjust claims for level of cover (limits and excesses)

<i>Policy Year</i>	<i>Upper</i>	<i>ILF (xs)</i>	<i>ILF (upper)</i>	<i>ILF</i>
2008	200	0.70	1.40	0.70
2009	200	0.70	1.40	0.70
2010	125	0.50	1.15	0.65
2011	125	0.50	1.15	0.65
2012	125	0.50	1.15	0.65
2013	150	0.70	1.25	0.55

<i>Policy Year</i>	<i>Adjusted Incurred</i>	
2008	600	$764 * 0.55 / 0.7$
2009	501	$638 * 0.55 / 0.7$
2010	269	$318 * 0.55 / 0.65$
2011	340	$402 * 0.55 / 0.65$
2012	118	$140 * 0.55 / 0.65$

Additional assumptions for ILFs:

- The ground up loss frequency is independent of the (limit) purchased.
- The ground up severity is independent of the number of losses and the limit purchased.

### Adjust claims for inflation

	Severity Trend	5%
	Frequency Trend	2%

<i>Policy Year</i>	<i>Exposure</i>	<i>Adjusted Claims</i>	<i>Trend</i>	<i>Trended Claims</i>
2008	209.0	600	1.4091	846
2009	211.5	501	1.3157	660
2010	214.5	269	1.2285	331
2011	212.0	340	1.1470	390
2012	211.5	118	1.0710	127
2013	213.0		1.0000	

- Assume claims in each policy year are paid/incurred on average at the same time relative to the start of that policy year (50% credit for assumption of claim incurred at midpoint of policy year).

### Develop claims

<i>Policy Year</i>	<i>% Dev</i>	<i>Ultimate</i>
2008	90%	940
2009	80%	824
2010	65%	509
2011	45%	867
2012	15%	846

### Project 2013 burning cost

2008	$4.5 = 940 / 209$
2009	3.9
2010	2.4
2011	4.1
2012	4.0

Explanation of rationale for selection:

- Older years more developed but less relevant
- Recent years more relevant but development uncertain
- No clear trend in burning costs for policy years
- 2010 looks anomalous
- Exposure is quite consistent

Calculation of overall burning cost rate as (total cost) / (total exposure)  
(e.g. 3.77 if using all years or 3.71 if using all but 2012)

[Alternatively, simple selection using burning cost for each year, e.g. 4]

Loss cost for 2013 = projected exposure \* projected burning cost  
(e.g.  $3.71 * 213 = 790$ )

*Some candidates did very well on this question, but some appeared to leave it unanswered when they got stuck on a particular aspect.*

*Because the question did not describe precisely how the policy limit operated, full credit was given for an alternative interpretation, where the limit was used as the "upper" point for the ILFs (instead of adding the limit to the policy excess). Partial credit was given for the inflation adjustment if the candidate used 7% instead of compounding. Full credit was given for executing the steps in a different order from that shown above.*

*Many candidates missed out on marks by not stating the correct assumptions. Several candidates stated as an assumption that no claims reach the limit per claim. Similarly, hardly any candidates gave more than one or two points of justification for the method used to arrive at the burning cost.*

*A disappointing number of candidates inflated the exposure by the rate of frequency inflation, but failed to realise that this would actually reduce the rate per unit exposure. Many also encountered difficulties with the time period over which the inflation was applicable.*

## **10 Premium rating basis (fundamental uncertainty)**

A motor insurer will try to set a premium based on past experience of similar business and then adjust these figures to reflect current and future market conditions.

This policyholder has no previous history as a qualified driver, so there is considerable uncertainty about her future claims experience.

The level of uncertainty is greater than for more experienced drivers.

### **Data Errors and Differences (one company has better data than another)**

Some insurers may have no data at all on this type of risk

e.g. if it's a new product or the company is entering the motor market for the first time (or other similar example)

Or data may be scarce

i.e. not enough claims data to provide a reliable model of risk.

e.g. low-frequency claims types, not enough history, sector bias, or similar example

Data may be inaccurate

e.g. incorrectly entered, or calculated

Missing data (*i.e. referring to missing columns, not to rows*)

e.g. MI system doesn't record some of the rating factors, especially if some of them are new (or other similar example)

Wrong level of detail or integrity problems

e.g. can't link claims to policies correctly, or amounts paid for each claim are not split by head of damage (or other similar example)

Data may be inadequately developed.

e.g. insufficient period left between the end of the exposure period and the analysis date so there are lots of missing IBNR claims (or other similar example).

Claims experience unusually good or bad (due to random fluctuations)

Treatment of PPOs and other large claims (which may not have occurred during modelling period)

### **Modelling Errors and Differences (one company models better than another)**

Different data may be selected or omitted prior to modelling

e.g. Different base periods used for the analysis, exclusion of open claims from analysis (or other similar example)

Differences in the type of modelling done, or level of sophistication. *[Note: this refers to type of modelling only, and not to the grouping of levels of factors (which is credited in the "smoothing" section, below)]*

e.g. sophisticated GLM for the risk premium v one-way tables (or other similar example)

e.g. customer demand analysis done or not done (or other similar example)

Differences in rating factor selection or model basis

Some factors may not be available to all insurers, or appear insignificant in explaining risk

e.g. new technology, such as telematics

Differences in parameter selection, smoothing & constraints

e.g. large BI claims modelled differently or different allowance for catastrophes (or other similar example)

e.g. smoothing of rates over variables like car age or policyholder age are subjective so one may be more accurate than another (or other similar example).

There may be a different approach to cross-subsidy within the model

e.g. NCD scales (or other similar example)

There may be a different level of modelling skill

### **Differences in Choice of Adjustment Factors**

Different views of the inflation of claim amounts ...

... and of trends in claim frequencies.

e.g. change in theft claims due to the economic environment, or legal expenses claims due to activities of claims management firms (or other similar example)

Different levels of expenses and commission applied to the risk premium.

e.g. because of the sales channel, or process efficiency (or other similar example)

Different allowance for investment income in the premium rate.  
e.g. different length of period assumed for payment of bodily injury claims (or other similar example)

Different reinsurance costs  
e.g. different levels and types of reinsurance used

Different assessment of (or appetite for) volatility of risks and therefore a different assessment of the contingency margin / extra profit margin required.

Different profit loadings or required return on capital  
e.g. different capital requirements due to diversification (or similar cause)  
e.g. or different appetite for high returns on that capital base (or similar cause)

Differences in other elements of the expense basis, such as taxation (or similar cause).

### **Market and Competition Differences**

Two companies may have different target markets  
e.g. through having different views of the lifetime value of different segments.

Two companies may have different risk appetites  
e.g. one wants young drivers on the books and targets them by giving lower premiums, whilst trying to upsell or cross-sell other business to replace the income stream.

Some companies may have a more well-known brand and can attract customers despite higher prices.

The quotes could have come through different sales channels...  
...with different competitive forces

Different companies may have a different idea of where they are in the insurance cycle, so pitch rates at a different level.

There may be changes in legislation, such as banning the use of gender in insurance pricing, and different companies will deal with the changed legislation differently

Although the cover is the same, other aspects of the customer experience may be different, which affects the premium.  
e.g. level of service quality, fringe benefits (or other similar example).

### **Accumulations**

An accumulation of the above factors likely to be necessary in order to produce the large discrepancy.

*Candidates often made valid points, but under a different heading. Where this was done, full credit was given.*



*Candidates often gave a general point without an example, or an example without generalising, hence missing marks. For instance, many gave “reinsurance” as an answer, but did not explain that different companies will have different levels and types of cover and, therefore, different reinsurance costs.*

*There was a wide variety in approaches to "fundamental uncertainty". The core reading refers here to the insurable risk that is transferred by the policyholder.*

*Lots of candidates made comments saying the insurer could be deliberately pricing itself out of a segment, or targeting certain customers, without giving any logic for this.*

*Many mentioned the use of external data, but this would probably tend to make premiums more similar, rather than different.*

*Candidates tended to talk about weather catastrophes, but very few mentioned large bodily injury claims and accumulations.*

## **END OF EXAMINERS' REPORT**

# INSTITUTE AND FACULTY OF ACTUARIES



## EXAMINATION

24 September 2013 (am)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 10 questions, beginning your answer to each question on a separate sheet.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

*In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.*

- 1** A general insurer underwrites cover for powerboats.

Explain why the insurer may choose to adopt a non-linear earnings pattern for premiums when analysing underwriting performance for this product. [4]

- 2** Under the collective risk model, the total claim amount  $S$  payable during a specified period in respect of a block of policies is

$$S = X_1 + X_2 + \dots + X_N,$$

where  $X_i$  is the claim amount payable during the period in respect of the  $i$ -th claim and  $N$  is the (random) number of claims during the period.

- (i) State the assumptions of the collective risk model. [1]

A general insurance company uses a collective risk model to determine the risk premium for a block of policies. It determines a distribution for  $X_i$  and  $N$  using the last five years of claims experience and then determines the risk premium using the following expression:

$$\text{Risk premium} = E(S) + 2\sqrt{\text{Var}(S)}.$$

- (ii) Comment on this choice of risk premium. [4]  
[Total 5]

- 3** Describe:

- (a) two different types of self-retention group, and  
(b) the reasons for using each type.

[6]

- 4** A general insurance company writes crop insurance across the United States of America. One of the perils covered by the policy is loss caused by tornados. The insurance company purchases reinsurance for the tornado peril.

- (i) Explain why experience rating is unlikely to be used by a reinsurance company in determining the reinsurance premium for this peril. [2]

A reinsurance company providing a quote for the reinsurance has a tornado catastrophe model that it has previously used for commercial property business. The reinsurer intends to adapt this model in order to use it for crop insurance.

- (ii) Explain the changes that the reinsurance company will need to make to the inventory and vulnerability modules of the model. [4]  
[Total 6]

- 5** The governing body of a developing insurance market has decided to create an industry-wide database. All general insurance companies in the market are required to supply quarterly data on business volumes and claims development at a specified level of granularity and using standardised data definitions. Data must be submitted within one month of each quarter end. All insurers will be able to read all of the data in the database.

Discuss the potential benefits of the database to the insurance market and problems that the insurers may experience as a result of this initiative. [8]

- 6** A general insurance company writes breakdown cover as an optional extra to the car insurance product that it offers. It has at least five years of detailed claims and exposure data relating to the breakdown cover. The pricing department is undertaking a review of past experience in order to set the risk premium for the following year.

- (i) Explain, giving examples, what adjustments to the past experience may be required. [6]

In order to boost sales of breakdown cover, the company has started negotiations with a car dealership that sells new and used cars. As an incentive to help car sales, the sales staff can give away this cover to car buyers.

- (ii) Suggest, with reasons, the further information required by the insurer to determine the appropriate risk premium for the free breakdown cover. [4]  
[Total 10]

- 7** A general insurance company currently writes household and private motor business only. It is planning to launch a product that provides a fixed benefit in the event of accident, sickness or unemployment.

- (i) Suggest reasons why the insurer may want to launch this product. [2]

The insurer has no experience of underwriting the new product but wants to determine a schedule of premium rates in advance of the launch.

- (ii) Suggest different ways in which the company could acquire the information to enable it to determine the premiums to charge. [3]

- (iii) Discuss the key indicators that the insurance company should monitor in the first few months following launch of the new product. [8]  
[Total 13]

- 8 (i) State the features of risk excess of loss reinsurance. [3]

A reinsurance company is pricing a risk excess of loss treaty that covers third party liability claims arising from mobility scooters on a large book of household insurance. The mobility scooters are single-occupant, electrically powered vehicles that are intended for people with impaired mobility to travel short distances outside the home, but are not classified as motor vehicles.

Mobility scooter cover is only provided under the contents section of the household insurance and policyholders are not required to disclose at the time of proposal how many mobility scooters they own, if any.

The reinsurance cover is \$9m excess of \$1m.

The reinsurance company decides to use exposure from the contents section only, i.e. “contents section years”, as the measure of exposure for pricing the mobility scooter cover.

- (ii) Comment on:

- (a) this choice of exposure measure, and
- (b) the advantages and disadvantages of other potential measures.

[3]

The cedant has provided the following data for the forthcoming treaty year.

Expected number of policies in force at start of year	288,280
Expected proportion of policies with a contents section	83%
Expected number of new policies written in year	19,000
Expected number of policies cancelling in year	9,000

The reinsurer estimates that the loss cost to the mobility scooter treaty per contents section year is 1.5% of the expected cost per vehicle year for a specific third party motor liability treaty. The reinsurer uses the following table of ILFs to adjust the motor liability treaty loss cost to the same layer of cover as the mobility scooter treaty.

<i>Limit (£m)</i>	<i>ILF</i>
1	1.000
2	1.463
3	1.703
4	1.843
5	1.931
10	2.096

The expected cost to the motor liability treaty per vehicle year is £6 for a layer £5m excess of £5m.

- (iii) Calculate the total expected loss cost under the mobility scooter treaty, showing all workings and stating any other assumptions that you make. [6]

The reinsurer uses the following basis to calculate the reinsurance premium:

Commission	20% of reinsurance premium
Expenses	15% of expected loss cost
Capital required to be held	77% of reinsurance premium
Required return on capital	12% of capital
Minimum rate on line	3%

- (iv) Calculate the reinsurance premium, showing all workings and stating any other assumptions that you make. [5]  
[Total 17]

- 9 (i) Outline intrinsic and extrinsic aliasing in a generalised linear model. [5]

A general insurance company writes household insurance through three brokers, Maul, Sidious and Vader. Sidious has recently moved its business to a new policy administration system, but in the process has lost details of the number of bedrooms of the insured properties. There are no other known data problems. Sidious intends to update its records when it next makes contact with each policyholder, but has so far had little opportunity to do so.

The insurer uses Number of Bedrooms and Broker as two of the factors in its pricing model, and currently holds the following data for these factors.

<i>Exposure (Policy Years)</i>		<i>Maul</i>	<i>Sidious</i>	<i>Vader</i>
<i>Number of Bedrooms</i>	0	6,270	0	5,277
	1	4,041	0	2,316
	2	15,687	0	9,183
	3	21,042	0	13,974
	4	12,663	17	8,112
	5+	2,577	0	1,290
	Unknown	0	13,953	0

- (ii) Explain:
- (a) the problems that the insurer may encounter when building a generalised linear model that includes these two variables, and
- (b) how it may choose to deal with these problems. [6]  
[Total 11]

- 10** A fleet policy covering a variety of motor vehicles is soon to expire. The broker placing the business has provided the following data and information relating to the most recent five years of cover.

<i>Policy year</i>	<i>Vehicle years</i>	<i>Number of claims</i>	<i>Total cost of claims</i>
1	1692	127	£286,000
2	1931	142	£350,000
3	2262	168	£413,000
4	2566	180	£458,000
5	2954	210	£565,000

Claims numbers and claims costs have been projected to ultimate.

Changes were made to the cover for the policies written in years 4 and later. The effect of this change is believed to have reduced average claims frequency by 5%, but to have had no impact on average cost per claim.

Claims cost inflation has been 3% p.a. over the last five years.

The number of vehicle years for policy year 6 is predicted to be 3050.

- (i) Calculate the risk premium for policy year 6, showing all workings and stating any further assumptions that you make. [8]

The following information is also available:

Expenses	40% of premium net of commission
Commission	10% of gross premium
Return on investments net of tax	8% p.a.
Profit margin net of tax	15% of premium net of commission
Insurance premium tax	Nil

- (ii) Calculate the gross premium for policy year 6, showing all workings and stating any further assumptions that you make. [6]
- (iii) Discuss why the premium calculated in part (ii) may not be an appropriate premium to charge. [6]

[Total 20]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

September 2013 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Introduction**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie  
Chairman of the Board of Examiners

January 2014



## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance actuarial and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the September 2013 Paper**

The level of difficulty of the paper and the general performance of candidates were similar to recent sittings. There was some evidence of time pressure amongst candidates around the pass-mark area, but most of these candidates appeared to have allocated their time in a disciplined way, so that they did not rush the later questions.

Poor handwriting was less of an issue at this sitting than in previous sittings, but there were still several instances where it was difficult for the examiners to read the script. Candidates who struggle with the legibility of their handwriting are asked to contact the Examinations Team well in advance of the sitting, for advice on what support may be available.

Question 8 contained an error, where a currency symbol appeared as £, rather than \$. Most candidates appeared not to notice, and those that did pick it up made a sensible assumption, so it did not seem to cause a significant problem. Question 9 on GLMs was disappointingly very low-scoring, despite being quite easy, but served to discriminate those candidates who had clearly grasped the topic.

Calculation questions that asked for assumptions and workings caused numerous problems in this sitting, and scores were disappointing as a result. The following problems were very common:

- Giving a formula without defining the terms or explaining anything, which made it difficult to give full credit.
- Giving no assumptions, or giving invalid or irrelevant ones. Candidates should take more care in this area, because there are significant marks available.
- Retaining either far too many or too few significant figures in intermediate calculations. Examiners try to be tolerant in this regard, but there are limits.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to include these areas in their revision.

**1**      Desire for earnings pattern to be consistent with incidence of risk

Using powerboats in poor weather may result in a greater incidence of claims

For example the risk may be higher in Winter and Summer due to poorer visibility/  
stormy conditions

However the risk may be higher in Summer than Winter if better weather leads to  
more congested waters

Desire for earnings pattern to be consistent with exposure

Usage of powerboats may not be constant throughout the year...

... therefore exposure is not uniform as assumed by a linear earnings pattern

This may be the result of people choosing not to use powerboats as much when the  
weather is poor

The insurer may intend to compare underwriting results with industry statistics, which  
may be compiled using a non-linear earnings pattern

Not adopting a non-linear earnings pattern for premiums the insurer may increase or  
reduce premiums unnecessarily

or make other inappropriate decisions e.g. sales strategies and target markets

*The examiners awarded separate marks for discussing non-linear exposure and non-linear intensity of risk, but many candidates only addressed one of these parts. Other candidates seemed to misunderstand the concept of an earnings pattern, and a number of candidates made unnecessarily detailed assumptions about the perils that would be covered under such a policy.*

**2**      (i)      the claim amounts  $X_i$ 's are independent and identically distributed

The  $X_i$ 's and  $N$  are independent of each other.

(ii)      This isn't a true risk premium

this would be  $E(S)$ , the expected loss cost

$\text{Var}(S)$  is a measure of the uncertainty/variability of the loss cost

Adding  $2 \times \text{std dev}$  therefore means they have incorporated a risk margin

...the size of which depends on the degree of uncertainty captured in the  
distribution chosen.

This would lead to a premium that is too high.

S can often be approximated by a Normal distribution (given sufficient claims)

Mean + 2\*std dev is a good approximation to the upper 97.5 percentile

It is appropriate to use data from the actual risk

The last five years may not be long enough if the experience is limited or very volatile

The claims from the more recent years may not be completely developed and will, therefore, need to be developed to ultimate

or five years may produce an answer that is skewed by out of date experience

The model assumptions may not be valid, for example the claim amounts may be correlated, leading to an incorrect estimate for the variance

The risk premium is completely experience rated and therefore gives 100% credibility to the experience of the block of policies, thus ignores external experience

it ignores judgement on future trends

it ignores claims inflation over the 5 years

May give risk premiums that do not reflect the likely long term experience of the block of policies – e.g. catastrophe events/unusually light or heavy experience

Easy to explain.

Should be easy to calculate

The risk premium gives equal weight to all years which may not be appropriate

The distributions chosen are subjective and may lead to incorrect results

The risk premium would have to be adjusted for any changes in the future risk profile

including cover level/terms and conditions/legislative changes etc.

*Many candidates scored relatively well on this question, but few commented that this does not reflect a true risk premium, or commented on the concept of a risk margin being added. A number of candidates included comments on items such as expenses and commission, which would not be expected to be included in a risk premium.*

### **3 Captive**

A company that is wholly owned by an industrial or commercial enterprise

Set up with the primary purpose of insuring the parent or associated group companies...

... and retaining risk within the enterprise

Reasons for setting up a captive include:

To fill gaps in insurance cover that may not be available from the traditional insurance market

To manage the total insurance spend of large companies or groups of companies/ avoid ceding profit to others

To enable the enterprise to buy cover directly from the reinsurance market rather than direct insurers

To focus effort on risk management

To gain tax and other legislative or regulatory advantages

Reduce impact of market cycles on premiums

Captives may also accept external risks on a commercial basis

#### **Pools**

An arrangement under which parties agree to share premiums and losses for specific insurance classes in agreed proportions

To some extent, all insurance is pooling

The main difference between insuring with a conventional insurer and insuring with a pool is that the insured's liability to an insurer is limited to the premium charged...

...whereas the liability to a pool will be related to the insured's share of the pool

Pools are commonly used to provide cover for large scale risks, such as atomic energy risks (or other suitable example).

**Protection and Indemnity (P&I) Clubs** are an example of pooling

These are mutual associations of ship owners.

Some of the largest clubs themselves mutualise in respect of very large claims

Originally formed to cover certain types of marine risks (e.g. liability)...

... that could not be covered at an acceptable price under a commercial marine policy.

Provide technical assistance and advice on issues relating to the shipping industry

*This question was generally answered well.*

- 4** (i) experience rating is not appropriate for low frequency, high severity risks
- as observed losses may not reflect the true underlying risk
- because the period over which losses have been observed may be much shorter than the return periods under consideration
- in some cases certain event scenarios may not have occurred in history
- for example, a five year burning cost model is unlikely to be reliable for pricing tornado risk if strikes are only likely every 25 years
- there will also be a lack of claims data exacerbated by high retention levels
- (ii) **Inventory module**
- SI / EML needs to be changed from buildings to crop value
- it will need to build an inventory of the different types of crops that may have to be covered (e.g. fruit, grain, root etc.)
- it will need to include the season in which the crops are grown i.e. summer or winter crops
- it will also need to know the geographical location of these crops as these will be in rural locations as opposed to the buildings which will be in urban areas/cities
- ..and their spatial coverage or the size of the farm on which the crops are grown (a crop will have a larger footprint than a building)
- they can build in temporal factors to reflect the growing stage of the crop over the season
- Vulnerability module**
- losses to crops will be a higher proportion of the sum insured than commercial property because
- a crop hit by a tornado will most likely be a total loss
- a commercial property (e.g. office block) hit by a tornado may suffer extensive damage but rarely a total loss
- the speed at which damaging losses occur will be much lower

crop damage will start occurring at relatively low wind speeds whereas commercial property damage will tend to occur at relatively high wind speeds

the vulnerability module is likely to be simpler with fewer parameters

crops will vary very little in their vulnerability

properties can vary significantly, and some may even be built to withstand tornado strike

consequential loss/business interruption may be required for commercial property, whereas no such thing would be required for crop,

and demand surge can inflate rebuild costs for commercial property following a catastrophe, which is not the case for crops

*Disappointingly, many candidates spent time stating bookwork, as opposed to applying this knowledge to the situation outlined in the question. In addition, candidates also overlooked the fact that the question asked for the changes that the company would need to make. It should be noted that the examiners did not require candidates to know the precise details of crop insurance in order to answer this question. The examiners gave appropriate credit for demonstrating understanding of the factors that should be considered, even if the detail was not correct.*

## **5 Benefits**

Compare own experience against that of other companies in the market...  
...both at the overall level and at the level of categories into which the data is classified

Helps to understand where business is different from competitors  
...so that they can identify growth opportunities

The ability to construct claims development data will help with reserving accuracy.

The above advantages will help improve pricing accuracy  
... and reduce the risk of insolvency e.g. due to anti-selection  
... and should give more choice and more competitive premiums

Standard data definitions will help with data quality  
... and consistency across participants and over time

Quarterly submissions should ensure that the data is reasonably up to date

Requiring submissions within one month of the end of each quarter will also ensure the data is up to date

Requiring all insurers to participate will ensure the largest possible dataset  
... and lack of bias to particular companies

By requiring large and established insurers to share data, it will help new entrants to the market  
....and existing insurers to enter new classes.

Requiring companies to demonstrate they hold good data reduces operational risk

Data sharing may assist in the identification of insurance fraud

It allows the regulator to monitor the activity of the market

### **Problems**

Potential for distortions due to heterogeneity if subdivisions too coarse

Insurer unable to segment data by the specified classification

Data provided by the scheme may not be comparable due to:

Companies operating in different sections of the market

Policies sold by different companies not the same (e.g. perils covered)

Companies have different practices (e.g. u/w, claims handling, etc.)

Data may not be stored or submitted in the same way

Rating factors may be coded in different ways

Market data slightly less up-to-date than internal data

Market data likely to be less detailed than internal data

May make some prices homogeneous, i.e. reduce competitiveness

Maintaining the database will be a cost to the market which is likely to be passed on to consumers

There may be errors in data submissions or misinterpretation of definitions and requirements

All of these could lead to the wrong conclusions being drawn from analysis

May be difficult/expensive/time consuming for companies to collect the data for submission. (e.g. data held by third parties)

There may be competitive disadvantages created for experienced companies that have to share their data with others

*In general, this question was answered reasonably well. Some candidates struggled to offer points that differed sufficiently from each other to score well.*



**6** (i) Adjustments include:

Develop claims from more recent periods to ultimate

– in order to allow for IBNR and IBNER claims

If the experience has been unusually heavy or light

– for example, a prolonged period of extreme weather or a manufacturing fault in a certain type of vehicle.

An adjustment will be required for any exceptional claims

Trends in claim frequency

– for example, cars becoming more reliable and therefore fewer claims or it becoming more common to run out of fuel and therefore more claims

Rebasing or allowing for trends in exposure

– for example, people driving less because of the escalating cost of motoring

Claims inflation – such as parts and labour

Changes in mix of business

– especially if the company has started writing through new channels  
– mix of new versus older or second-hand cars

Changes in cover

– for example, the company may have changed excesses or limits etc.

Changes that affect claimant behaviour, such as an NCD scale.

Changes in underwriting

– Stricter on the types, age or quality of cars underwritten resulting in better claims experience

Changes in sales method, e.g. whether it is bundled with other covers

Legislative changes

E.g.,

– for example, the law may change so that in future broken down vehicles are towed to specific locations  
– or that accommodation is made available  
– or that a hire car must be provided

Claims handling processes

– improvements in fraud measures  
– action taken to reduce claims leakage (e.g. better training of claims handlers and more quality checks)

- (ii) How will the product be rated, i.e. a flat rate per car sale, or using rating factors?
- Using rating factors means changing mix is less of a concern
  - However car dealership unlikely to want to collect rating factors, especially those about the policyholder.

How old are the cars they sell? – new ones are less likely to breakdown.

Will there be a difference in selection risk?

E.g., depending on

- whether the cover is available to all customers
- whether certain customers already have cover independently
- whether customers remember that they have the cover when a claimable event occurs

To what extent does the garage carry out inspections on used cars?

The use of the cars sold (e.g. private use or fleet/taxis) and coverage (e.g. abroad?)

This may reduce overall exposure

Will the same cover be provided to each buyer, and if not how will it differ?

What make of cars are they selling?

E.g.,

- they may be more/less reliable than average
- and/or they may be easier and cheaper, or more expensive to get going again.

Claims experience of policyholder/claimant behaviour from any other similar business ventures in the past.

When will the new rates be in force?

How long will the cover be for?

*Many candidates spent time discussing items that would not form part of the risk premium, such as commission. Others wrote at length about competitor premiums and sales volumes, which again would not form part of the risk premium. Relatively few candidates were able to demonstrate commercial awareness by thinking of real-world situations. Very few candidates mentioned trends in exposure in Part (i), or the selection risk in Part (ii).*

7

- (i) To grow the business, i.e. new source of GWP

To grow profit.

– fixed expenses may be spread more thus reducing per policy expenses (economies of scale)

To meet demands from brokers/advisors/policyholders and therefore make the insurer's whole proposition more attractive.

– this is also beneficial when tendering for business with new partners.

To differentiate their offering from other insurers in a competitive personal lines market

To increase diversification

– as accident, sickness and unemployment insurance risks are likely to have low correlation with household and motor.

As the benefit is fixed, claims will have low volatility

leading to (relatively) lower capital requirements, and therefore potentially reducing the return on capital required.

To increase cross-selling opportunities to the other products.

- (ii) Front the business with an experienced insurer to begin with until own experience is gained.

Coinsure with a more experienced underwriter.

Obtain assistance/advice from reinsurers, consultants or brokers

Employ actuaries and underwriters with previous experience in this line of business.

Track the market, i.e. research and replicate market pricing structures.

Obtain claims data from government/industry-wide/medical research data collection schemes, if any exist.

The insurer could purchase another insurer's product book of business including the existing rating structure, as well as exposure and claims history

(iii) Quote volumes.

Monitor effectiveness of marketing campaigns.

Which channels are most effective at drawing quotes.

Suggests possible marketing strategies.

Analysis of actual initial expenses and commission compared with expected.

Helps to assess rating adequacy/profitability.

Quote distribution/mix.

This indicates the types of risks likely to be attracted through different channels.

Again, suggests possible marketing strategies.

Conversion rate/strike rate.

High conversion could suggest premiums are cheap relative to the competition.

Conversely low conversion suggests premiums are expensive relative to the competition.

Analysing conversion rate by rating factor may reveal problems with the rating structure, or opportunities.

Test live rates to ensure algorithm has been implemented correctly

Monitor discounting activity (if permitted) at point of sale

New business volumes.

Volumes should be consistent with those expected in business plans, but differences may arise due to

market reaction to launch  
marketing activity  
other suitable reason.

Volume should be monitored to ensure policy admin staff are able to deal with increased work load.

Capital and reinsurance requirements may also need to be reviewed if volumes different to plan.

Not-taken-up rates or early cancellations.

Should be similar to household and motor – higher rates should be investigated.

Can detect fraudulent behaviour e.g. if cash-back or other offers available.

Should be examined by distribution channel to ensure miss-selling is not an issue.

Mix of business – is it as expected?

A high penetration in a certain rating cell could indicate the insurer is being selected against.

Cross-subsidies (if any) may compromise profitability if mix is not as expected.

Comparison with competitors' rates

To identify opportunities to gain profit per policy or overall volumes.

Early claims experience.

and claims declinature rate

To identify problems with policy wording, poor underwriting or fraud ideally by channel or source of business.

*Part (i) was generally answered well. In part (ii), most candidates suggested obtaining assistance from reinsurers and industry-wide data collection schemes, but few were able to make further suggestions. In part (iii), it was disappointing to note that very few candidates recognised that any claims experience would be very immature, with a number of candidates suggesting in-depth claims investigations that could be carried out. Along similar lines, a number of candidates suggested monitoring lapse rates, which would require policies to have been invited to renew.*

## **8** (i) Non-proportional reinsurance.

Indemnifies the cedant for the amount of each individual loss

... above a stated excess point.

Normally subject to an upper limit.

There are normally multiple layers (including a working layer), each coming into operation when lower layers are fully burnt through.

The excess point and upper limit may be fixed, or indexed as specified in a stability clause.

There should be not gaps between layers and the indexation/fixation of the layers should be consistent in order to avoid unforeseen exposure to risk.

There may be a deductible percentage within a specific layer, to reduce moral hazard.

There may be reinstatements, either free or subject to an additional premium.

There might be a profit commission.

- (ii) Potentially proportional to risk (at least the risk should be a monotonically non-decreasing function of exposure).

Practical measure, i.e. available, acceptable, verifiable and measurable.

Use of the contents section only prevents distortion from the buildings or other sections.

Ideally, we would use scooter year

but there is no data available from the cedant.

However, this is not a great measure, as there will be a lot of variation in the extent of scooter exposure.

Contents sum insured or premium could be an exposure measure related to the scooter risk

because (all else equal) more scooters should mean a higher SI and higher premium

these measures are easily available

but the relationship is not very strong.

Scooter miles would also be related to the scooter risk

but would be very difficult to verify

- (iii) *There is a misprint in the question – \$ should be £. Full credit was given to any candidate who dealt with this appropriately.*

Assume that ILFs do not need adjustment for inflation.

Assume the (ground-up) loss frequency is independent of the limit purchased

Assume the (ground-up) severity is independent of the number of losses and of the limit purchased

Assume that business is written on a losses occurring basis

Assume that treatment of loss adjustment expenses is consistent between the motor and scooter treaties.

To adjust the motor treaty loss cost to the scooter treaty, we use the formula

$$\begin{aligned}L_S &= L_M * [\text{ILF}(10) - \text{ILF}(1)] / [\text{ILF}(10) - \text{ILF}(5)] \\&= L_M * [2.096 - 1] / [2.096 - 1.931] \\&= L_M * 6.64242\end{aligned}$$

Assume that movements (new business and cancellations) occur evenly throughout the year

...so that these policies get half a year's exposure.

Assume that the proportion of policies with a contents section is the same for new business and cancellations as for the rest of the book.

$$\text{Contents section exposure} = [288,280 + (19,000 - 9,000)/2] * 0.83$$

Alternative assumptions are acceptable if calculation method is consistent

$$= 243,422$$

$$\text{Expected loss cost for scooter treaty} = 243,422 * £6 * 1.5\% * 6.64242$$

$$= £145,522$$

- (iv) Assume that investment income is negligible.

Assume no other loadings (retrocession, profit commission etc.)

Assume that RoC is a one-year calculation, i.e. no residual value at the end of the year.

Solution variant 1:

RIP = Claims + Expenses + Commission + Capital charge

$$\text{Expenses} = 0.15 * 145,522 = 21,828$$

$$(\text{or Claims} + \text{Expenses} = 1.15 * 145,522 = 167,351)$$

$$\text{RIP} = 167,351 + (\text{RIP} * 0.2) + (\text{RIP} * 0.12 * 0.77)$$

$$\text{RIP} (0.8 - 0.0924) = 167,351$$

$$\text{RIP} = 167,351 / 0.7076$$

$$= £236,505$$

Solution variant 2:

$$\text{RoC} = (\text{RIP} - \text{Claims} - \text{Expenses} - \text{Comm}) / \text{Capital}$$

$$0.12 * 0.77 * \text{RIP} = \text{RIP} * 0.8 - \text{Claims} * 1.15$$

$$\text{RIP} (0.8 - 0.0924) = \text{Claims} * 1.15$$

$$\text{RIP} = £145,522 * 1.15 / 0.7076$$

$$= £236,505$$

$$\text{Minimum premium} = 0.03 * 9,000,000 = 270,000$$

So premium charged is the higher of the two, i.e. 270,000

*Part (ii) was answered very well by some candidates, but very poorly by others, with some suggesting factors such as age or mobility of the policyholder, which are unlikely to be practical. In part (iii), many candidates either failed to state assumptions, or made them too vague. This is a recurring theme. In part (iv), a significant proportion of candidates ignored the minimum premium aspect of the question.*

## 9 (i) Intrinsic Aliasing

- Occurs due to inherent dependencies in definition of covariates
- Most commonly arise where categorical factors are included in the model
- For example, a factor “occupied during the day” has the levels  $X_1 = “Y”$  and  $X_2 = “N”$ , so if  $X_1 = 1$  then  $X_2$  must be 0, and vice versa (or similar categorical factor example).
- Intrinsic aliasing is overcome by giving each factor a base level
- This is normally done automatically by GLM software...
- ... but the choice of base level will depend upon the software used

### Extrinsic Aliasing

- Also occurs due to dependencies in definition of covariates...
- ... but due to nature of the data instead of properties of covariates themselves
- Occurs when one level of a factor is perfectly correlated with a level of another factor
- For example, if in the data in Part (ii) all of the exposure for Sidious were in the Unknown category, these rating factor levels would be perfectly correlated.
- In this case, one of the levels of one of the factors needs to be removed from the model.
- Again, the GLM software would normally do this automatically.

## (ii)

- The data provided by Sidious will result in near aliasing
- The “Unknown” level of number of bedrooms is almost but not perfectly correlated with Sidious...



- ... so extrinsic aliasing will not occur
- and the GLM software will not remove parameters from the model.
- Convergence problems can occur as a result of near aliasing
- e.g. if there are no claims for the 17 exposures, and a claims frequency model is built using a log link, we could have large and opposite-signed parameters for Sidious and Unknown number of bedrooms (or other similar example)
- Whilst this may give an appropriate projection for the 13,953 exposures from Sidious with Unknown number of bedrooms, the value of the Sidious parameter would be driven by the experience of only 17 exposures
- The results could be confusing or misleading
- Ask Sidious to correct its data
- Ask for an extract of data from the old system
- Reclassify the 17 exposures to the “Unknown” category
- Exclude the 17 exposures from the model
- Consider excluding one of the factors from the model
- Use offsets to fix some of the relativities, which may help the model to converge
- Whatever the action taken, it is important to ensure that the pricing scheme is still able to generate a sensible price for any combination of rating factor levels
- Obtain additional data, if available...
- ... and estimate the correct distribution of bedrooms from this

*On the whole, this question was disappointingly low-scoring, despite examining relatively basic concepts. Many candidates demonstrated a clear misunderstanding of the different types of aliasing. Very few candidates mentioned how GLM software would deal with aliasing, despite this being stated clearly in the Core Reading. However, a small proportion of candidates demonstrated very good knowledge of this area of the syllabus, and scored high marks.*

10 (i)

<i>U/W year</i>	<i>vehicle years</i>	<i>claims</i>	<i>total cost</i>	<i>frequency</i>	<i>frq adj for new cover</i>	<i>frq for new cover</i>
1	1,692	127	286,000	0.075059	0.95	0.071306
2	1,931	142	350,000	0.073537	0.95	0.069860
3	2,262	168	413,000	0.074271	0.95	0.070557
4	2,566	180	458,000	0.070148	1	0.070148
5	2,954	210	565,000	0.071090	1	0.071090
Total	11,405					

<i>U/W year</i>	<i>year 6 money terms</i>		<i>average cost</i>	<i>"As-if" total cost (=exposure * frq * acpc)</i>
1	1.159274074	331,552.39	2,610.65	314,974.77
2	1.12550881	393,928.08	2,774.14	374,231.68
3	1.092727	451,296.25	2,686.29	428,731.44
4	1.0609	485,892.20	2,699.40	485,892.20
5	1.03	581,950.00	2,771.19	581,950.00
Total				2,185,780.08

Risk premium = Yr 6 exposure \* (Total historic as-if cost) / (Total historic exposure)

= 584,536

(e.g. taking average frequency and cost per claim over the five years gives the following risk premium :  $3,050 * 0.0705923 * 2,708.33 = 583,121.89$ )

assume no significant change in mix of business which could change frequency and/or severity in year 6

assume completely experienced-rated

assume claims inflation will be 3% for the next year

assume no trending of the frequencies/average costs required

no trend apparent in the adjusted frequency or adjusted ACPC

(ii) Assume claims and expenses occur evenly over the year...

... therefore, expenses and claims outgo occur at mid-point of year.

Treat profit as an up-front loading, which is reasonable as it is a percentage of premium, but other timings are allowable.

Assume inv income rate is annual effective

Assume commission is paid at the start of the policy year.

The answer below assumes a front-loaded profit. Equal credit was given if an alternative assumption is made regarding timing and the correct discount factor is used.

Let:

$Df$	be discount factor	= 1.03923
$Er$	be expense rate	= 40%
$Pm$	be profit margin	= 15%
$Cr$	be commission rate	= 10%
$RP$	be risk premium	= £584,536
$NP$	be net premium	
$GP$	be gross premium	

Equation of value:

$$GP = \text{Commission} + (RP + \text{Expenses})/(\text{discount factor}) + \text{Profit}$$

$$\begin{aligned} NP &= (RP + er*NP)/df + pm*NP \\ NP &= RP/df + er*NP/df + pm*NP \\ NP(1 - er/df - pm) &= RP/df \\ NP &= RP/(df - er - pm*df) \\ GP &= NP / (1 - cr) \end{aligned}$$

$$\begin{aligned} NP &= £1,209,353 \\ GP &= £1,343,725 \end{aligned}$$

*Alternative Approach*

$$GP = \text{commission} + \text{profit} + (\text{expenses} + \text{claims})*(\text{discount factor})$$

$$\begin{aligned} GP - \text{commission} &= \text{profit} + (\text{expenses} + \text{claims})*(df) \\ 0.9*GP &= 0.15*0.9*GP + (0.4*0.9*GP + 584,536)*(1.08)^{(-0.5)} \end{aligned}$$

$$\begin{aligned} 0.9*GP &= 0.135*GP + (0.36*GP + 584,536)*0.9622504486 \\ 0.9*GP &= 0.135*GP + 0.3464101615*GP + 562,470.0283 \\ 0.4185898355*GP &= 562,470.0283 \end{aligned}$$

$$GP = 1,343,725$$

Alternative answer with mid-year profit assumption:

$$\begin{aligned} GP &= \text{Comm} + (RP + \text{Exp} + \text{Profit})/df \\ NP &= (RP + (er + pm) * NP) / df \\ NP &= RP/df + er*NP/df + pm*NP/df \\ NP(1 - er/df - pm/df) &= RP/df \\ NP &= RP/(df - er - pm) \\ NP &= £1,194,806 \\ GP &= £1,327,563 \end{aligned}$$

Alternative answer with end-year profit assumption:

Let  $df2 = 1.08$

$GP = \text{Comm} + (RP + \text{Exp})/df + \text{Profit}/df2$

$NP = (RP + er*NP)/df + pm*NP/df2$

$NP = RP/df + er*NP/df + pm*NP/df2$

$NP(1 - er/df - pm/df2) = RP/df$

$NP = RP/(df - er - pm/df)$

$NP = \text{£}1,181,136$

$GP = \text{£}1,312,373$

- (iii) Business objectives – could be trying to grow book

Competition may impact on achievable volumes and mix

Position in insurance cycle

e.g. by colouring judgment (tide of optimism)

e.g. takes time for real claims performance to become known/cyclical effects on reserving levels

A different premium may be charged depending on customer price elasticity.

The level of cover may have changed over the years (e.g., excesses)

Cross-subsidies may allow the premium to be discounted if bundled with other covers e.g. breakdown.

Similarly, a special rate may be given if the insured has already purchased other insurance from the insurer

Changes in regulation mean inflation and claims cost projections need to be revised.

The fleet mix/exposure changes significantly.

- e.g. new information received on size of fleet/type of vehicles
- the fleet may have changed its rules about who can drive
- the use of the vehicles may have changed (e.g. may now carry dangerous goods)

The insurer may want to include a large claim loading based on experience with similar books of business

Number of vehicle years may not be as predicted

Likely to have a retrospective adjustment to allow for changes throughout year 6

It may be advisable to apply a loading for contingencies or to allow for volatility in claims experience

The last five years may have been unusually light/heavy

Other soft factors e.g. the fleet employs its own engineers and vehicles are examined after each trip

Might not be able to get capital at same cost as assumed

The cost of reinsurance might need to be included.

More recent years might be considered too underdeveloped to give equal weighting in claims cost

It might be considered that there is insufficient allowance for external effects such as bodily injury trends

There might be a regulatory constraint on rating levels

There might be a minimum premium per vehicle

The premium may have to be adjusted to ensure the Broker relationship is not affected

*Part (i) was generally well answered, but part (ii) saw lower marks. In general, candidates failed to show enough in the way of clear workings. This makes it difficult for examiners to follow their reasoning and to offer partial credit where mistakes were made. In part (iii), better candidates linked their answer to the scenario stated in the question, as opposed to making more general points.*

## **END OF EXAMINERS' REPORT**

# INSTITUTE AND FACULTY OF ACTUARIES



## EXAMINATION

30 April 2014 (am)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 12 questions, beginning your answer to each question on a new page.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

*In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.*

- 1** In a pricing exercise many adjustments are required to the exposure and claims data from the base period to the period in which the rates will be in force.

State the causes of delays that could lead to adjustments being made. [3]

- 2** Outline the regulatory restrictions that may be faced by a general insurance company, excluding those relating directly to investments. [5]

- 3** The operator of a ski centre requires business interruption cover to insure against financial losses resulting from low numbers of visitors. The insurance policy will pay a fixed benefit if the number of visitors on any one day is lower than a predefined level.

Suggest terms and conditions that the insurer may include in the insurance contract to manage the cost of claims. [4]

- 4** A reinsurance company is assessing the expected losses from a proposed inwards reinsurance treaty covering liability insurance.

The cedant has supplied the following information about the policies that it expects to write, summarised into bands of excesses and layer sizes.

<i>Band</i>	<i>Excess (€m)</i>	<i>Size of layer (€m)</i>	<i>Written premium (€)</i>	<i>Expected loss ratio</i>
A	1	1	37,000	40%
B	1	9	14,000	45%
C	10	5	48,100	35%
D	10	10	8,700	30%

The following increased limit factors (ILFs) are available.

<i>Limit (€m)</i>	<i>ILF</i>
1	1.000
2	1.585
3	1.992
4	2.298
5	2.539
10	3.263
15	3.635
20	3.863

The proposed reinsurance treaty covers 100% of total losses in the layer €10m in excess of €5m for each risk individually.

Calculate the cedant's expected recoveries under the treaty for each of Bands A to D, showing all workings. [6]

- 5 A modelling exercise, using a large batch of travel insurance policies, has resulted in two generalised linear models being built to predict claims cost.

The following information and statistics have been produced for the two models:

	<i>Model 1</i>	<i>Model 2</i>
Factors included in model	Policyholder age Number of travellers Length of holiday	Policyholder age Number of travellers Length of holiday Country of destination
Deviance	365,128	362,144
Number of parameters	15	24
Number of observations	3,156,582	3,156,582
Akaike information criterion	365,158	362,192
Scale parameter	1.15567	1.15958

Explain, using the information in the table above, which model is preferred. [7]

- 6 A general insurance company underwrites two different household insurance products. One is only available in bank branches, and the other is only available over the telephone.

The product sold through bank branches includes additional policy sections, and provides more cover in all other policy sections, than the telephone product. After the initial sale the administration and claims processes are identical for the two products.

The Sales Director has obtained a quotation for each product on the same day using identical answers to the questions on the proposal. The price for the telephone product is higher than the price for the branch product, and the Sales Director wishes to know the reasons for this.

Describe the different types of investigation and analysis that should be carried out to answer the Sales Director's query. [8]

- 7 A general insurance company is considering changing the level of compulsory excess on the private motor insurance policy that it sells. The existing level of £250 has been in place since the policy was launched. A voluntary excess is not available on this policy.

(i) Outline the adjustments required to the insurer's data, in order to set the correct risk premiums for a new compulsory excess level of £300. [3]

(ii) Explain the difficulties that could arise in determining the risk premiums if the company instead reduces the excess to £200, suggesting how these difficulties may be overcome. [3]

[Total 6]



- 8** (i) Describe the main features of professional indemnity insurance. [5]

A general insurance company is assessing the premium for professional indemnity cover for one of its clients.

Analysis of past data shows that the compound frequency-severity loss distribution for a single employee has the following properties:

Mean	500
Standard deviation	200
Coefficient of skewness	2

- (ii) Determine the parameters of the translated gamma distribution that should be used to approximate the compound distribution. [3]

The client has 40 employees. The insurance company prices the cover so that there is a 1% probability of claims exceeding the gross premium, assuming that losses for different employees are independent.

- (iii) Calculate, using a Normal approximation to the compound distribution, the gross premium that the insurance company would quote. [3]  
[Total 11]

- 9** (i) Outline the fundamental concepts of credibility theory. [3]

- (ii) Outline the key differences between the Classical and Bayesian credibility models. [3]

- (iii) State the principles that should be considered when choosing the complement of credibility. [6]  
[Total 12]

- 10** The regulatory body of a developed insurance market is considering making flood insurance a compulsory component of household insurance policies for the first time.

- (i) Suggest the data items that would be required by insurers operating in the market to price the claims risk of this component of the insurance contract. [4]

As a consequence of making flood insurance compulsory, it has been agreed that the government of the country will pay all flood claims from insured domestic properties that have been determined as being at an extreme risk of flooding.

To meet the cost of these claims, all insurers will pay a fixed levy into a central fund for each household insurance policy that they write, regardless of the insured property's level of flood risk.

- (ii) Suggest the factors that the government will need to consider, in order to determine the amount of this levy. [6]  
[Total 10]

- 11** A general insurance company uses a proprietary earthquake catastrophe model to price the earthquake element for commercial property. The model was last updated ten years ago.
- (i) Suggest the features of the event, hazard and vulnerability modules of the catastrophe model that are likely to have become outdated since the last update. [7]

The company receives an updated version of the earthquake catastrophe model.

- (ii) Outline how the company should use the model to help to estimate the claims cost of the earthquake cover. [5]  
[Total 12]

- 12** A general insurance company is planning to use a frequency/severity approach to price an all-risks policy that covers the sales outlets of a large retail group. The company has provided this insurance to the retail group for many years.

The following table shows an incomplete extract from the available data concerning the insured as at 1 March 2013. The data values are for illustration only.

<i>Sales outlet Code</i>	<i>Policy year</i>	<i>Days on risk</i>	<i>Turnover (£)</i>	<i>Employees</i>	<i>Deductible (£)</i>	<i>Sum insured (£)</i>	<i>Policy limit for liability section (£)</i>
...							
9001	2009	365	365,509	4	1,000	700,000	5m
9001	2010	365	367,881	4	1,200	840,000	10m
...							
9002	2012	181	436,000	6	2,000	1m	10m
...							
<i>Outlet</i>	<i>Loss date</i>	<i>Claim status</i>	<i>Paid (£)</i>	<i>Outstanding case estimate (£)</i>	<i>Policy section</i>		
...							
9001	5/9/2009	Closed	93,008	0	Stock		
...							
9002	21/1/2013	Open	3,000	2,000	Public liability		
9002	20/2/2013	Open	0	Unknown	Employers' liability		
...							

The policy will include an aggregate deductible and limit.

Describe, without performing any calculations, how the company should use the available data to build a frequency/severity model for the purpose of pricing. Details of how to carry out statistical tests are not required. [16]

**END OF PAPER**







# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

April 2014 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Introduction**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

D C Bowie  
Chairman of the Board of Examiners

July 2014

## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance actuarial and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the April 2014 Paper**

The level of difficulty of the paper and the general performance of candidates were similar to recent sittings. There was no evidence of time pressure in this paper around the pass mark area, despite the higher than normal number of questions.

Yet again, a number of candidates displayed poor handwriting at this sitting, which made it difficult for examiners to award full credit. Candidates who struggle with the legibility of their handwriting are asked to contact the Examinations Team well in advance of the sitting for advice on what support may be available.

Question 9 was a relatively straightforward bookwork type question on credibility, but candidates did not generally score well. Answers to question 11 often suggested that candidates know the basics about catastrophe models but do not actually understand how they work in practice. Scores for question 12 were highest amongst those whose answers followed a methodical approach.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates are advised to include these areas in their revision.

- 1** Time taken for sufficient claims experience to develop from the historical data  
Time taken to analyse the claims experience  
Time taken to reach and agree the new premium rates and premium structure  
Time for testing the new prices before implementation  
Time taken to administer and implement the new rates (including communications)  
Waiting for current marketing offers to expire before introducing the new rates  
Time taken to prepare new marketing material/offers for the new rates  
There is often a delay between the occurrence and notification of a claim  
There is often a delay between the notification and settlement of a claim  
Time taken for any approval needed from a regulatory body  
Reinsurance recovery delays  
Waiting for exposure information from third parties (e.g. brokers)  
Information about claims if being handled by a third party may be delayed

*Most candidates focused on reporting and settlement delays, failing to pick up on the many other delays that arise in a pricing exercise.*

- 2** Restrictions on the type of business that can be written or the classes for which the insurer is authorised  
Restrictions on the amount of business that may be written  
Restriction upon the territories in which the insurer may write business  
Controls on the premiums rates that can be charged...  
...e.g. by requiring the insurer to file rates with the regulator, or publish in advance, or imposing min/max rates  
Restrictions on the information that may be used in underwriting and rating, e.g. EU Gender Directive  
Restriction on the types, or amounts, of assets that can be held to demonstrate solvency



Restrictions upon the ability to write business unless:

Assets are deposited to back claims reserves

A minimum level of solvency is maintained...

...measured in a prescribed manner

Prescribed bases are used to calculate premiums, assets and liabilities for demonstrating solvency

Individuals are authorised to hold key roles

Agents are licensed to sell insurance

Levies are paid to consumer protection bodies/funds

Reinsurance of suitable quality/amount is purchased

Financial returns are supplied to the regulator at prescribed intervals

Data protection measures are followed

Policyholder protection measures/complaints procedures in place

Renewal terms are offered to certain groups of policyholders

Restrictions regarding the acceptable methods of sale, and the information that must be disclosed during the sale process

Restrictions on the minimum level of cover (perhaps unlimited) that must be offered for certain classes of business

Restrictions upon the proportion of certain types of business that must be written

Restrictions upon Mergers and Acquisitions

*Generally well answered with most candidates scoring highly.*

**3** List specific causes covered, to avoid unforeseen causes

Specify any exclusions e.g. War

Avoid any cause that is within the insured's control (to avoid moral hazard)

but allow closures in the interests of visitor safety, e.g. avalanche threat

Ensure that the benefit doesn't exceed normal profit per visitor (to avoid moral hazard)

Ensure that the visitor threshold is not set too low compared with the normal visitor level

Restrict number of consecutive days covered

Restrict number of days covered in any year, or specify a maximum annual benefit

Allow for differences in visitor numbers depending on the season

Cap the exchange rate if the benefit is in a different currency from the normal for the book

This is a form of business interruption cover so should only apply where this cover doesn't already exist (e.g. commercial fire)

The company will require proof of the number of visitors and

the means of qualifying for a claim will have to be clearly defined

e.g. if the required number come in the morning but the centre has to close at midday and the visitors get a partial refund

The insurer may want to restrict the length of time between the claim event and claim notification

Requirement for ski centre to maintain facilities to reasonable standard, including staffing levels

Changes in entrance fees require prior agreement

Introduce a no-claims discount / put in place a profit share arrangement

*This question was reasonably well answered, but a significant minority made suggestions that would not be practical, or contradicted the question – for example an excess is not appropriate when the benefit is fixed.*

4

<i>Band</i>	<i>Excess</i>	<i>Top of ceded cover</i>	<i>Effective retention</i>	<i>Effective RI top</i>	<i>Proportion of expected loss in reinsured layer</i>	<i>Cedant's expected losses</i>	<i>Expected recoveries</i>
B	1	10	5	10	0.320	6,300	2,016
C	10	15	10	15	1.000	16,835	16,835
D	10	20	10	15	0.620	2,610	1,618

Band A is entirely below the excess point of the treaty so there is no recovery (expected recoveries=0).

Band C is entirely within the limits of the treaty, i.e. 100% reinsured  
Recovery for Band C is  $48,100 \times 35\% = 16,835$

For Bands B and D, the formula for the proportion of the expected losses that fall in the reinsured layer is:

$$[\text{ILF(RI top)} - \text{ILF(RI excess)}] / [\text{ILF(cedant top)} - \text{ILF(cedant excess)}]$$

The size of the reinsurance layer in the formula must be restricted if necessary, in order to reflect the effective reinsurance coverage for the band.

#### Band B

$$\begin{aligned}\text{ILF (RI top)} &= \text{ILF (10)} = 3.263 \\ \text{ILF (RI excess)} &= \text{ILF(5)} = 2.539 \\ \text{ILF (cedant top)} &= \text{ILF(10)} = 3.263 \\ \text{ILF (cedant excess)} &= \text{ILF(1)} = 1\end{aligned}$$

$$\text{Expected recovery} = 6,300 * (3.263 - 2.539) / (3.263 - 1)$$

#### Band D

$$\begin{aligned}\text{ILF (RI top)} &= \text{ILF (15)} = 3.635 \\ \text{ILF (RI excess)} &= \text{ILF(10)} = 3.263 \\ \text{ILF (cedant top)} &= \text{ILF(20)} = 3.863 \\ \text{ILF (cedant excess)} &= \text{ILF(10)} = 3.263\end{aligned}$$

$$\text{Expected recovery} = 2,610 * (3.635 - 3.263) / (3.863 - 3.263)$$

*Better candidates scored full marks in this straightforward question. A disappointing number failed to realise that no recovery was possible for Band A and that a full recovery would be made in Band C.*

**5** It would seem sensible to include the country of destination as a rating factor...

...as visiting different countries would be likely to result in differences in claim frequency...

... and severity...

e.g. Medical expenses, flight delays, weather events, theft, etc.

The models are nested

Difference in number of parameters =  $24 - 15 = 9$

Two nested models can be compared using a  $\chi^2$  test...

...as the change in scaled deviance i.e.  $D_1^* - D_2^* \sim \chi^2_{df1-df2}$

Scaled deviance,  $D_1^* = 365,128 / 1.15567 = 315,945$

Scaled deviance,  $D_2^* = 362,144 / 1.15958 = 312,306$

Difference in scaled deviance,  $D_1^* - D_2^* = 315,945 - 312,306 = 3,639$

Upper 5% point of  $\chi^2_9$  is 16.92 ( credit given up to 10%)

$3,639 > 16.92$  hence implying that Model 2 is a better fit

OR This implies a p-value of 0.0%

...hence implying that Model 2 is a better fit.

There is a reduction in AIC going from Model 1 to Model 2...

...suggesting that Model 2 provides a better fit.

*Most candidates scored well for the calculation parts of the question, but only the better candidates looked beyond the statistics and considered whether the additional factor was actually sensible.*

## **6** Verification

Replicate the difference by re-running the cases if possible

Speak to the Sales Director or otherwise check how the quotes were run (or check details entered, or other check on the quote process)

Run a basket of risks through both quote engines to see if this is an isolated case, or quite common (perhaps plot the distribution of premium differences).

#### Data and models

Investigate whether data quality for building models on the two channels is equally good.

Look for errors in the pricing engine or model

#### Cost of claims

See if the cost of claims is lower for the branch-based product, even though cover is higher

Check whether the same rating factors are used

Collect data and adjust as necessary for the model being used

For example, adjust for inflation (or other valid example)

Include a variable for channel/product

Use a method that separates channel/product from other explanatory factors, e.g. GLM

Is it possible to tell if it is the channel or the product that drives the claims cost differences? Perhaps use data on historical products

See if there are sections that have very low total claims amounts, i.e. cover is not really significantly better for the branch product

...or very few claims over a certain amount

See if there is more of a concentration of risk with the telephone product

...or other increased risk level (e.g. increased fraud or other valid example)

...has this led to a higher volatility charge?

This might be seen by looking at an external model or catastrophe model.

#### Expenses

Analyse expenses by channel / Investigate the differences in the cost of running the two different channels.

Split by:

Commission  
others incurred on inception of the policy

Within the above expenses, a split of fixed and variable expenses is needed.

Investigate any different reinsurance costs.

Compare the results of the expense analysis with the loadings in the prices.

Strategy, profitability and return on capital

Establish what (if any) cross-subsidies have been included in the prices

Or other deliberate strategies, such as trying to boost or suppress sales in one channel (or other valid example)

Look at price gradient from NB to subsequent renewals to see if it is steeper for the branch product

See if this is justified by models of customer lifetime value, and/or investigate elasticity, renewal demand, cancellations, up-sales

Look at the capital model to see if these factors are driving a higher capital loading for telephone product.

Marketing

Establish whether there were any special offers or price tests, or different negotiable margins running in the channels

*This question was generally poorly answered. Whilst many were able to state why there might be differences, few gave any details about the investigations and analysis that should be carried out, thus failing to answer the question.*

**7** (i) Inflate all claims to the same point in time...

... usually 6 months after the mid-point of the period in which the rates are deployed.

Adjust for any other differences in cover, i.e. put it all on constant cover basis

Remove any types of claim that do not carry a compulsory excess (e.g. windscreens, third party liability).

Develop claims to ultimate

Consider whether to adjust for periods of particularly heavy or light claims experience,...

... or for any other known trends or environmental factors

Subtract £300 from each claim if claims are recorded from the ground up,  
or subtract £50 from each claim if only paid is recorded.

Any resulting negative claims can be removed from the analysis.

A more sophisticated approach may also eliminate smaller resulting claims, to allow for policyholders not claiming for small amounts.

Changing the excess may attract a different mix of business, probably to more careful drivers.

- (ii) The complication arises because it is unlikely that policyholders will report claims that are below the current excess of £250.

Similarly for claims that are just above £250 if NCD system in operation

Therefore the company will have very little reliable data below this amount

It will be necessary to estimate the increased number of claims

and estimate the increase in size of future claims.

Data may be available from other similar products, or from external sources.

Otherwise, we must use more approximate adjustments, based on any knowledge available regarding the claim cost distribution

The extent of the effect of reducing the excess will also depend on any no claims bonus system in operation.

An increase in the number of claims may increase claims leakage.

A change in excess level could lead to an adverse mix of business

*This question was generally well answered. In part (i) many of the answers lacked detail about the adjustments required. Only the better candidates recognised that claims just above the excess might not be reported if a no claims bonus system is in operation.*

- 8** (i) Professional indemnity cover is a type of liability insurance.

It indemnifies the insured against legal liability to pay compensation to a third party ...

... for losses resulting from negligence in the provision of a service,

for example:

incorrect advice from a solicitor,  
or unsatisfactory medical treatment,  
or other suitable example

Legal expenses are usually also covered

There are several types of professional indemnity insurance sold, including Directors' and Officers' and Errors and Omissions cover

The perils depend on the profession,

The most common exposure measure is turnover

Risk and rating factors include type of profession and number of employees

It is usually written on a claims-made basis.

Claims are usually long-tailed, owing to legal disputes

Professional indemnity is prone to accumulation risk (a successful legal case may lead to more claims)

It is often a legal, professional or regulatory condition of being allowed to practise a profession,

There are excesses, per claim and per annum limits

Illegal acts will be excluded

- (ii) Equate first three moments

$$\text{Mean} = 500 = k + \frac{\alpha}{\delta}$$

$$\text{Variance} = 200^2 = \frac{\alpha}{\delta^2}$$

$$\text{Coefficient of skew} = 2 = \frac{2}{\sqrt{\alpha}}$$



Solving gives

$$\alpha = 1$$

$$\delta = 0.005$$

*A negative value for  $\delta$  is not valid.*

$$k = 300$$

(iii) For 40 employees

$$E(S) = 40 \times 500 = 20,000$$

$$\text{Var}(S) = 40 \times 200^2 = 1,600,000$$

Want  $p$  such that  $P(S > p) = 0.01$

Let  $S \sim N(20,000, 1,600,000)$

$$P(S > p) \cong P\left(Z > \frac{p - 20,000}{\sqrt{1,600,000}}\right) = 0.01$$

$$\Rightarrow \frac{p - 20,000}{\sqrt{1,600,000}} = 2.3263$$

$$\therefore p = 22,943$$

*This question was well answered, but a surprising number of candidates were unable to give a precise definition of professional indemnity insurance. Parts (ii) and (iii) caused few problems, though a common mistake was incorrectly calculating the variance for the Normal approximation.*

**9** (i) Credibility theory is used to calculate quantities that feed into a pricing structure...

...such as expected claims frequency or average claims amount

It allows for the consideration of actual experience...

...as well as external information...

The external information is known as the complement of credibility.

The calculated quantity used in pricing is normally expressed as a weighted average of those obtained from the observed data and external data sources (*credit given for an appropriate formula*)

The external data is given more weight if there is limited observed data...

...or if the observed data varies significantly from one period to another

(ii) Classical credibility

Can be used where estimates of  $E[s^2(\theta)]$  and  $\text{Var}[m(\theta)]$  are not available

Defines the standard for full credibility, i.e. how much data is required before full credibility can be assigned to the actual experience

It then uses this standard for full credibility to calculate the credibility factor

Often used in the calculation of overall rate increases

Simpler to work with, and easier to explain

Bayesian credibility

Never reaches  $Z = 1$

Generates more accurate insurance rates where estimates of  $E[s^2(\theta)]$  and  $\text{Var}[m(\theta)]$  are available.

(iii) Practical Issues

Readily available

and up to date

Ease of computation...

...leading to ease of communication

...and less chance of error

Cheap to produce

Competitive market issues

If rates are too high, competitors can undercut the rate and still make a profit...

...leading to loss of customers and profit

If rates are too low, the company will lose money

Therefore the rate should be unbiased (not too high or too low)...

...and accurate (as low an error variance as possible)

#### Regulatory issues

Should have an explainable relationship to the loss cost of the class

May need some level of approval from regulator

Classic regulatory law requires that rates be “not inadequate, not excessive and not unfairly discriminatory”

#### Statistical issues

Must consider all types of error that make up the prediction error...

...i.e. the squared difference between the credibility weighted prediction and actual results

Errors in the type of model used (model error)

Errors in the specific parameters selected (parameter error)

Independence from the base statistic

*The responses to this question were mixed. Parts (i) and (ii) were generally poorly answered with only the better prepared candidates demonstrating a good understanding of the differences between Classical and Bayesian credibility. In part (iii) most candidates generated a good number of the desirable properties.*

**10** (i) Location of property, e.g. postcode, or individual address point

Distance from water

Height above water

Claims history of historical flooding...

Type of historical floods (cloud burst vs. river basin vs. coastal flood risk)

Flood defence precautions taken at the property

Flood defence precautions taken in the local area

Drainage system quality in the area

Number of floors, or which floor the property is on

Type of property (e.g. house, flat)

Construction materials

Rebuild cost

Value of contents

Cost of alternative accommodation

Post event inflation / demand surge

Output from a flood cat model

Restrictions imposed by regulatory requirement (e.g. excess levels, cover levels etc.)

(ii) Factors affecting outgo from the fund

Precise definition of “extreme risk”

Number of properties that are at extreme risk

Distribution of claim costs

Average claim frequency

Expenses and management costs for setting up the scheme

Cost of capital required to be held by the fund

Improvements to flood defences

Inflation

Demand surge

Projection of weather patterns

Progress of coastal erosion

Who handles/settles claims attributable to fund (outgo may differ depending upon whether the claims are handled directly by the fund or by the primary insurers)

Other running costs, for example IT systems

Factors affecting income to the fund

Number of household insurance contracts sold

Investment income on the fund's assets (linked to size of fund)

Reduced sales in low-premium areas due to additional levy to subsidise the high flood risk properties

Other factors

Time required for the fund to be operational

How claims will be dealt with in the period until the fund has built up sufficient funds

Levy may change over time when sufficient funds exist

Availability and cost of reinsurance

Building up a buffer for future claim events

Public reaction as the cost of the levy will be passed onto all policyholders but not all of them are exposed to flood risk.

Introduction of the scheme may change the behaviour of people and companies, e.g. less caution over moving to properties, or building properties in high flood risk areas.

*Part (i) was generally well answered, but part (ii) saw lower marks. In part (i) many gave points about insurance in general but not flood in particular. In part (ii) few mentioned the practicalities of setting up and running such a fund, missing out on many of the available marks.*

**11** (i) Event Module – location and frequency

In the last ten years, new research will have improved understanding of how earthquakes are triggered.

The last ten years may also have produced earthquake events that have never been witnessed before (either in size or location or both) and these should be added to the event set.

...these may change the risks of recurrence

Measurement sophistication is always improving and model parameters can now be estimated more accurately.

The improvements in computing power mean that stochastic models can now be run more efficiently meaning more simulations and therefore better estimation.

Digital terrain mapping is always evolving at ever higher resolutions, thus improving the location intelligence of events.

#### Hazard Module – magnitude

Research into rock formations or soil type at earthquake prone locations will have improved, ...

... as well as the understanding of how they are affected by different sized earthquakes.

There will also be improved understanding of where fault lines lie and in particular their depth, and how this affects the magnitude of an earthquake.

Research will also have developed in terms of size, location and frequency of aftershocks.

#### Vulnerability Module – structural damage

In the last ten years it is likely that much work will have been done to improve building techniques and construction materials...

...hence newly built properties should be resilient to all but the most extreme earthquakes...

Older properties may also benefit from new construction techniques and materials that may help provide support to buildings.

Improved awareness/education of the public including better warning systems...

...which may lead to speedier disaster recovery, and thus limit consequential loss.

Improved understanding of the impact of aftershocks

Improved understanding of quality of construction by location.

- (ii) Create an inventory module – the insurer will have to list all its exposures in as much detail as the model can utilise.

This is likely to include:

- a measure of location (postcode, cresta zone)
- property type/use (shop, warehouse, manufacturing plant, hotel)
- Property construction

Property age  
sum insured or EML

Any significant expected changes to the portfolio mix should be factored in.

Parameterise the financial module.

This is likely to include:

Excesses/deductibles  
Limits  
Exclusions  
Business interruption or consequential loss  
Reinsurance treaties in place  
Demand surge

Run the proprietary model to determine the expected annual loss cost for the portfolio.

Or use the OEP/AEP outputs in a stochastic frequency severity model to simulate losses in a year

This could be pro-rated per policy in some way:

e.g. by sum insured;

Or more accurately by a combination of the drivers of earthquake risk cost, such as sum insured and location and construction type.

It is important that the user reads the model's user manual.

*This question was poorly answered, demonstrating a lack of understanding of catastrophe models in practice. Many candidates believed that the vulnerability module needs to be modified for changes to the insurer's exposure. However, the question relates to a proprietary catastrophe model and the inventory module is where exposure is specified. In part (ii) most recognised the need to update the inventory module and parameterise the financial module, but few gave sufficient details about what this actually involved.*

## **12**    Preliminary checks

Carry out data checks, such as cleansing and reconciliation

Check that the claims and policy data correspond correctly

### Obtaining base values

Group the exposure/policy data by major risk type/type of cover

Data in "policy section" could be used for this.

Group the exposure/policy data by policy year

provided that there is sufficient data.

It is assumed in that each outlet has the same policy sections

For each class, obtain:

- Reported loss count/number of claims (from the loss data given)
- Exposure measure
- Individual loss costs

Suitable exposure measures would be:

- Sum insured for property-related risks
- Turnover for public liability
- Number of employees for employers' liability

...each multiplied by the proportion of the year on risk (use "days on risk" for this)

#### Developing losses

Develop the reported loss counts to obtain ultimate loss numbers.

This involves estimating the reporting delays and IBNR

Deal with catastrophe losses separately:

- Remove them from the analysis
- Estimate them using a specialist model
- Add an allowance back into the overall analysis

Develop individual loss amounts to obtain ultimate loss costs.

Claims can be developed using case estimate development factors on open claims only (or other valid method).

Ideally, the development factors would be based on the insurer's own experience.

However, if these are not available or credible, it may use a benchmark pattern.

Allow for any changes in reporting and settlement delays.

When developing the losses, bear in mind the deductibles and limits that apply for each sales outlet for each policy year.

Estimate the ultimate costs for any IBNR losses.

For new/unknown attritional losses, use other similar developed losses for the insured.



Deal with large losses by truncating them at a certain level

...and adding back a separately modelled adjustment.

Frequency = (ultimate number of losses) / (exposure measure)

Average severity = (ultimate cost of losses) / (ultimate number of losses)

### Trending

Inflate the historical estimates to current values

and then project them to the mid-point of the future exposure period (or period of claims payment).

Include a further allowance for trends on top of inflation.

Do this separately for frequency and severity.

The observed pattern of historical experience for the risk can be used as an indication of the trend to apply, but it is more common to apply a standard trend.

This may be based on the insurer's whole portfolio or publicly available sources such as industry or statistical bodies.

Inflate the turnover and sum insured exposure measures because these are monetary.

### Adjusting to new policy Ts&Cs

Historical losses must be adjusted if they arose under different terms & conditions from those that will apply in the forthcoming period of exposure.

One approach is to develop standard curves to adjust frequency and severity for deductibles, limits etc.

Limits and deductibles may need to be adjusted for inflation.

Exclude losses that would not be covered in future loss years (e.g. due to an additional exclusion).

Add an allowance for any new types of loss likely to become evident over time.

### Fitting the model

Choose the base period to use for fitting.

Older years will be more developed (less error introduced by estimating development)

Recent years are more relevant (less error introduced by adjusting to prospective Ts&Cs and trending/inflation).

The extent of this will depend on the cover type

For example, stock is shorter tailed than liability (or other valid example)

So the company must decide which years to down-weight or exclude.

Base period should be longer for long-tailed classes like EL

Fit distributions to frequency and severity using statistical techniques,  
combined with expert judgement/"sanity checks"/external benchmarks.

Common distributions for frequency include Poisson and negative binomial.

Common distributions for severity include log-normal, Weibull, Pareto, gamma.

Different severity distributions may be used for different parts of the loss range.

Catastrophe losses would come directly from the cat model and bypass the fitting process.

It is likely that a simulation (/Monte Carlo) approach would be needed...

...to deal with the combination of individual and aggregate deductibles and limits

#### Applying to the prospective period

Combine frequency and severity to obtain the overall loss cost.

Express the final premium as a rate per unit of exposure...

...so that it is adjustable if the exposure changes.

*The candidates who scored highest in this question structured their answer in the way they might approach this in practice (such as in the solution above). A disappointing number of candidates used a scatter-gun approach, thereby failing to generate a sufficient number of distinct and valid points. In many cases answers also lacked detail – for example most identified the need to estimate IBNR losses but few explained that, as a frequency/severity model was used, it would be necessary to estimate the number and the value of these losses.*

## **END OF EXAMINERS' REPORT**

# INSTITUTE AND FACULTY OF ACTUARIES

## EXAMINATION

30 September 2014 (pm)

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You have 15 minutes before the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have three hours to complete the paper.*
3. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 11 questions, beginning your answer to each question on a new page.*
6. *Candidates should show calculations where this is appropriate.*

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

<i>In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.</i>
---

- 1** (i) Define the general insurance term *captive*. [2]
- (ii) Outline the circumstances under which lighter regulatory capital requirements may apply to a captive. [1]
- [Total 3]

- 2** (i) Describe the cover offered by directors' and officers' liability insurance, giving two examples of the perils covered. [3]
- (ii) Define the term *claims made policy*. [1]
- (iii) Explain why directors' and officers' liability insurance would usually be written on a claims made basis. [2]
- [Total 6]

- 3** (i) Outline the features of a good rating factor. [4]
- (ii) Suggest rating factors that could be used for a travel insurance product. [3]
- [Total 7]

- 4** A general insurance company is quoting for renewal of a large employers' liability policy. The coverage is due to change as follows:

	<i>Excess per claim (€)</i>	<i>Limit per claim (€)</i>
Previous underwriting years	10,000	10m
Forthcoming underwriting year	15,000	15m

The company wishes to develop losses from previous underwriting years to their ultimate level and use them in a frequency/severity model for the forthcoming underwriting year, where the new excesses and limits will apply.

Discuss the issues that the company should consider when developing the losses. [8]

**5** A reinsurance company is quoting for a property catastrophe reinsurance contract.

When the contract exposures are run through a catastrophe model, the outputs in the table below are obtained. The mean annual loss of £850,000 is also an output from the model. The catastrophe model allows for all losses that can occur under the contract after all policy conditions have been applied.

<i>Occurrence Exceedence Probability</i>	<i>Loss (£)</i>	<i>Aggregate Exceedence Probability</i>	<i>Loss (£)</i>
0.001	6,720,568	0.001	9,079,743
0.002	5,699,379	0.002	8,169,830
0.004	5,209,773	0.004	7,377,621
0.005	5,019,663	0.005	6,906,690
0.01	4,542,104	0.01	5,632,374
0.02	3,850,841	0.02	4,596,968
0.04	3,041,600	0.04	3,979,562
0.1	2,227,807	0.1	2,646,802
0.2	1,100,136	0.2	1,327,115
0.5	129,434	0.5	165,377

The following definitions are used:

- “Gross premium” is the premium charged to the cedant.
- “Net premium” is gross premium net of brokerage.
- “Underwriting profit/loss” is net premium, less expenses and ultimate claims.

Brokerage is 10% of gross premium and other expenses are 15% of net premium.

As well as the cost of claims and expenses, the net premium includes:

- a volatility margin of 8% of the largest individual event loss in a year at the 1-in-100-years level, and
- a charge of 10% of the capital required to be held.

The capital requirement is 70% of the underwriting loss (i.e., the negative profit) that would result from aggregate losses over a year at the 1-in-200-years level.

Derive the gross premium to be quoted for the contract, showing all workings. [7]

- 6** A general insurance company specialises in insuring properties in areas that are exposed to hurricanes. It uses catastrophe models that include an event set that is designed to represent 10,000 years' worth of hurricanes.

(i) Outline how it is possible to generate such an event set. [3]

Some recent hurricanes have produced large losses to the company, so the company wants to investigate the accuracy of the vulnerability module. It has already investigated the other modules and is satisfied that they are performing adequately.

(ii) Define the term *vulnerability module*. [1]

(iii) Describe the investigations that would be conducted. [6]

[Total 10]

- 7** An insurance industry association classifies private motor cars into one of 50 groups for the purpose of insurance pricing, based on similarity of vehicle characteristics.

(i) Suggest factors that may be appropriate for defining this classification. [4]

(ii) Discuss the advantages and disadvantages to a motor insurer of using its own vehicle classification, rather than that of the industry association, for pricing motor insurance. [6]

[Total 10]

- 8** A pricing analyst is carrying out a burning cost calculation for a property insurance policy.

The following data are available on exposure and claims:

<i>Underwriting year</i>	<i>Sum insured (\$m)</i>	<i>Excess per claim (\$)</i>	<i>Paid claims (\$)</i>	<i>Claims development factor</i>
1	0.5	500	255	1.00
2	0.7	500	170,877	1.00
3	1.0	1,000	-	1.01
4	1.3	1,000	9,001	1.05
5	4.0	4,000	2,553	1.20
6	8.0	4,000	-	1.80
7	6.0	3,000	18,088	2.10

The analyst determines the burning cost as follows:

<i>Underwriting year</i>	<i>Ultimate claims (\$)</i>	<i>Ultimate claims per \$m sum insured (\$)</i>
1	255	510
2	170,877	244,110
3	0	0
4	9,451	7,270
5	3,064	766
6	0	0
7	37,985	6,331
Average		36,998

It is intended that the overall average rate of \$36,998 be used as one of the inputs to determine the price for the forthcoming renewal in year 8, when the sum insured and excess are expected to be the same as for year 7.

Discuss the sources of inaccuracy in the analyst's method, suggesting how these could be reduced. [11]

- 9 (i) State the advantages and disadvantages of purchasing excess of loss reinsurance. [2]
- (ii) Outline the features of aggregate excess of loss reinsurance. [3]

A Lloyd's syndicate insures large industrial plants across the world against fire, storm and flood. The syndicate is due to renew its existing outwards reinsurance contract, which gives catastrophe excess of loss cover for claims arising in the underwriting year. The syndicate has provided the information shown in the table below to its reinsurance broker. The information relates to losses experienced on the contract.

<i>Underwriting year</i>	<i>Event ID</i>	<i>Loss (\$m)</i>
2008	ST1-08	10
2008	FL1-08	30
2009	ST1-09	5
2011	FL1-11	20
2011	FL2-11	35
2012	FI1-12	5
2012	ST1-12	2
2012	FI2-12	3

- (iii) Set out the further information that is required to price this reinsurance contract. [7]
- [Total 12]



- 10** A linear regression model of pet insurance claim frequencies comprises two independent variables, namely type of pet and age of pet. The model is used to predict annual claim frequencies for cats and dogs. The table below summarises the frequency of claims from a recent dataset.

*Claim Frequency*

Young cat	34%
Young dog	63%
Old cat	15%
Old dog	70%

The model can be written in matrix form as:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta}$$

where the responses  $Y_i$  are independent and Normally distributed with common variance  $\sigma^2$ ,  $\mathbf{X}$  is the design matrix, and  $\boldsymbol{\beta}$  is the vector of parameters.

- (i) Specify for the model, assuming a base level of “old cat”:
  - (a) the vector of parameters
  - (b) the design matrix, including a row for each of the observations
  - (c) definitions for the columns of the design matrix

[4]
- (ii) Calculate the predicted values for  $E[\mathbf{Y}]$  by minimising the sum of squared errors, showing all workings.
 

[8]

[Total 12]

- 11** A general insurance company writing mainly motor and household insurance uses generalised linear models to predict the number and cost of claims on policies. The insurer builds separate models for each peril. Each month the pricing department submits a report to the management team showing how actual claims experience in the previous month compares with that predicted by the models.

- (i) Explain why such a report should be produced.
 

[4]
- (ii) Explain the most likely causes of the differences between actual and predicted experience.
 

[10]

[Total 14]

**END OF PAPER**

# **INSTITUTE AND FACULTY OF ACTUARIES**

## **EXAMINERS' REPORT**

September 2014 examinations

### **Subject ST8 – General Insurance: Pricing Specialist Technical**

#### **Introduction**

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context at the date the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

F Layton  
Chairman of the Board of Examiners

December 2014

## **General comments on Subject ST8**

Subject ST8 deals with applications of general insurance pricing techniques across many different types of product. Candidates should expect the examiners to draw these applications from all parts of the syllabus in order to test as wide as possible a range of skills and, in particular, to achieve a fair balance between personal and commercial lines.

Examiners will sometimes require the use of standard general insurance actuarial and statistical techniques that are covered in earlier subjects. Candidates should ensure that they are familiar with these when preparing for the ST8 examination.

As well as pricing techniques, ST8 also covers the workings and use of reinsurance products, so candidates should also expect the examiners to set questions on these aspects.

In questions with an element of calculation, different numerical answers may be obtained from those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations. Candidates are not penalised for this. However, candidates may be penalised where excessive rounding has been used or where insufficient working is shown. Where questions require looking up values in tables, candidates are expected to interpolate between two values if reasonable to do so, even when this is not stated in the question.

Where examples are given in the solution to illustrate the points made, marks were awarded to candidates who gave these particular examples or an equally valid alternative.

## **Comments on the September 2014 Paper**

The level of difficulty of the paper and the general performance of candidates were similar to recent sittings. There was no evidence of time pressure in this paper around the pass mark area.

Yet again, a number of candidates displayed poor handwriting at this sitting, which made it difficult for examiners to award full credit. Candidates who struggle with the legibility of their handwriting are asked to contact the Examinations Team well in advance of the sitting for advice on what support may be available.

Bookwork questions were generally well answered, and better prepared candidates successfully tailored the answers to the questions, instead of making more general comments. Candidates did not score well on questions 6 and 10, despite question 10 closely reflecting an example given in the Core Reading.

The comments that follow the questions concentrate on areas where candidates could have improved their performance. Candidates approaching the subject for the first time are advised to concentrate their revision in these areas.

- 1** (i) An insurer wholly owned by an industrial or commercial enterprise
- ...set up with the primary purpose of insuring the parent or associated group of companies
- ...and retaining the premiums and risk within the enterprise (subject to reinsurance).
- A captive may insure external companies but strictly speaking this is not a true definition of captive.
- [2]
- (ii) If the purpose of the captive is to provide cover exclusively for the risks of the undertaking or group to which it belongs and so does not provide cover for third parties or other insurable risks outside the group.
- If the captive demonstrates good risk management or achieves risk diversification.
- [1]  
[Total 3]

*Part (i) was generally answered well, however a considerable number of candidates did not give a sufficiently detailed answer to be awarded full marks. In part (ii), many candidates did not refer to the first of the above points, despite this being stated in the Glossary of Terms.*

- 2** (i) D&O insurance indemnifies the insured against the legal liability to compensate third parties...
- ... owing to any wrongful (or negligent) act of the insured in his or her capacity as a director or officer of a company.
- The insurance is personal to the director or officer,
- but is usually bought for him or her by the company.
- The perils include financial loss arising from:
- allowing a company to continue operating in circumstances when it should have been declared insolvent.
- any act resulting in the insured being declared unfit for his or her role.
- allowing false financial statements to be published.
- Legal expenses are also usually covered.
- [3]

- (ii) A policy that covers all claims reported to an insurer within the policy period ...  
... irrespective of when the incident occurred.

There is normally a retroactive date, after which the incident must have occurred in order to be covered.

[1]

- (iii) For the perils covered, it is usually not possible to determine the actual loss date.

For example, at what point should a company be declared insolvent, or what happens if there is a series of wrongful acts?

So a claims made basis avoids disputes over which insurer is liable,

and reduces the risk of a losses-occurring insurer no longer being able to cover the claim.

The insured (the company purchasing the D&O cover) wants protection against unknown incidents which may have occurred in the past but only affect the performance of the company in the future.

This basis leads to shorter tailed cover for the insurer, so underwriting years can be closed more quickly/less reserving risk.

This basis of cover might be required by law/regulation.

[2]

[Total 6]

*Parts (i) and (ii) were generally answered well, however few candidates provided enough information to gain more than one mark in part (iii).*

- 3** (i) A good rating factor should:

help explain the risk as much as possible

remove heterogeneity within each rating cell

have little correlation with other rating factors

...in order to minimise the number of questions and reduce administrative costs

be practical to obtain and record

not be open to interpretation/manipulation by the customer/applicant

be objective

be verifiable

be acceptable to the customer/applicant

be acceptable to the industry/to the regulator/market/legally

preferably remain constant over time.

[4]

(ii) Single trip, annual

Duration of trip

Countries covered/destination

Single person, couple, family (number of people)

Activities included/excluded (e.g., skiing, diving)

Optional limits or extensions chosen (e.g. value of luggage, piste closure)

Non-controllable characteristics of insured, such as age or sex

Type of trip (e.g. cruise/backpacking/business etc.)

Previous claims history

Existing medical conditions

Voluntary excess chosen

[3]

[Total 7]

*This question was generally answered well, with candidates demonstrating a good knowledge of travel insurance. Credit was given to other suitable suggestions.*

**4** If the losses are not from the ground up, then they should be converted to FGU by adding the excess.

Each individual loss amount should be adjusted to its expected ultimate level...

...rather than only developing the aggregate amount for a cohort of claims.

A development factor is needed for each claim, according to its characteristics.

The issue here is how to classify the development factors, for example by:

- type of claim or peril
- maturity of the claim
- claim status (open or closed)
- claim size

Aggregating or subdividing the factors in different ways can result in higher or lower factors.

It is important to know whether the development factor contains an allowance for claims inflation or trends.

Particularly court decisions or awards that may change future claims patterns.

Adjustments for claims development, trends and monetary inflation would ideally be separated and the adjustments made in successive steps.

These can make a large difference when considering the portion of the claim that falls above the excess point or above the limit.

The development factor must also be appropriate to the loss, i.e. preferably ground up.

It is important to include (or estimate) claims whose incurred (paid + case reserve) amount is below the previous excess, because some of them may go above the new excess after development.

It is also important to include (or estimate) claims whose incurred (paid + case reserve) amount is above the previous limit, because some of them may fall under the new limit.

Claims over 10m might have been capped at 10m, in which case an estimate is needed to assess their full value.

Claims should be before outwards reinsurance.

The reported loss count for each historical policy period should also be developed to ultimate (to allow for IBNR).

For IBNR, an assumption of ultimate size is needed...

...which is normally based on the known losses and reporting delays.

This will depend on the reporting delays experienced.

Development factors might not be available, or might lack credibility.

Older underwriting periods will tend to be less relevant than newer ones.

For example, they may relate to periods when:

- the nature of the insured's business was different (risk management, size, processes, type of employee)
- the risk was underwritten by different insurers, or the claims handling processes were different
- claims or legal environment was different
- policy terms and conditions were different (other than excess or limit)

However, more recent periods are less developed.

There might be unusually heavy or light experience (e.g., an accumulation of claims from a single event) in the data, which needs to be adjusted for.

Estimates will be uncertain, so a development method that yields a range might be needed.

If the insurer does not have appropriate internal development factors it can use it should consider the use of benchmark claims development patterns.

ILFs may be useful if available as a comparison/check.

Due to the long tailed nature of EL cover, tail factor development may be necessary.

[8]

*This question was generally poorly answered. Many candidates failed to tailor their answer to the question, giving points that were too general. Relatively few candidates recognised that individual (as opposed to aggregate) claims needed to be developed, and few candidates recognised why the changing excess was an issue for developing losses.*

## 5 Define:

$P$  net premium  
 $K$  capital charge

Building up the net premium from the components specified in the question:

$$P = 850,000 + 0.15 * P + 0.08 * 4,542,104 + K$$
$$0.85P = 850,000 + 363,368 + K$$

$$(1) \quad 0.85P = 1,213,368 + K$$
$$\text{or } P = 1,427,492 + K / 0.85$$

Underwriting profit at 1:200 level, as specified in the question:

$$\text{Profit} = P - 6,906,690 - 0.15 * P$$
$$= 0.85P - 6,906,690$$



So capital charge ( $K$ ) is 10% of 70% of  $(6,906,690 - 0.85P)$

$$(2) \quad K = 483,468.3 - 0.0595P$$

Solving the simultaneous equations (1) and (2), e.g. by adding them and cancelling  $K$ :

$$0.85P = 1,213,368 + 483,468.3 - 0.0595P$$

$$0.9095P = 1,696,836$$

$$P = 1,865,680$$

$$\text{Gross premium} = P / 0.9 = 2,072,978$$

**A more algebraic solution is also possible, with numbers substituted as a final step, as follows.**

Define:

$P$  net premium

$C_E$  expected annual recovery

$V$  volatility charge

$K$  capital charge

$E$  expenses excluding commission

$C_K$  annual recovery at the 1 in 200 level

$r$  capital charge rate applied to UW profit at 1:200 level

$$(3) \quad P = C_E + V + K + E$$

Underwriting loss at 1:200 level is:

$$-(P - C_K - E)$$

$$= -(C_E + V + K - C_K) \text{ (using equation 3)}$$

$$\text{So, } K = -r (C_E + V + K - C_K)$$

$$K(1 + r) = -r (C_E + V - C_K)$$

$$(4) \quad K = (C_K - C_E - V) \cdot r / (1 + r)$$

Substituting equation (4) into equation (3) gives:

$$P = C_E + V + E + (C_K - C_E - V) \cdot r / (1 + r)$$

$$P - E = (V + C_E + r \cdot C_K) / (1 + r)$$

$$C_E = 850,000$$

$$V = 8\% \text{ of}$$

$$4,542,104 \text{ (from OEP table)}$$

$$= 363,368$$

$$C_K = 6,906,690 \text{ (from AEP table)}$$

$$\text{So } P - E = 1,585,829$$

$$P = 1,585,829 / 0.85 = 1,865,681$$

$$\text{Gross premium} = P / 0.9 = 2,072,979$$

[7]

*Candidates who adopted a systematic approach to answering this question generally scored well. It is noted that the two approaches shown above offer slightly different answers. Candidates were not penalised where their answers differed slightly due to rounding.*

**6** (i) Past experience is used as an input.

However, the period of observation of past events is normally much shorter than the return period of the events.

A scientific understanding of the underlying causes of the natural hazards is used.

Allowing for changes to weather patterns such as global warming and latest research on hydrodynamics and meteorology.

And geographical information systems (GIS) software.

Together, these provide a basis to create other possible future events including ones that have never been observed historically.

[3]

(ii) The vulnerability module measures the degree of loss to a particular system or structure

...resulting from exposure to a given hazard (often expressed as a percentage of sum insured).

[1]

(iii) What is possible will depend on the volume and accuracy of the data available.

For each historical storm:

Obtain detailed storm data suitable for input to the cat model,

...such as track, max wind speed, radius, forward speed, rate of decay of wind field

Obtain the corresponding exposures at the time

...with detail on exposures to analyse vulnerability:

Construction type e.g. steel, wood frame

Age

Location

Number of storeys

Property type  
Occupancy type  
Other valid suggestion

Run the data through the Catastrophe model and capture the expected losses

Ensure the actual losses are projected to ultimate

...and adjusted for time value of money to a specific point in time.

Compare the losses coming out of the model with the actual losses.

Segment the losses to find areas of significant difference.

For example:

By exposure factor (see above)  
By occupation e.g. office, restaurants  
By type of coverage e.g. flood

Consider any “one off” factors unusual to the storms  
e.g. another large event at the time causing a massive demand surge.

The vulnerability model relies, partly, on data and assessments from  
engineering studies etc.,

...so we might also want to consider:

how comprehensive these were  
how long ago they were done

If possible, check the results using another Catastrophe model.

Check whether the module is up-to-date

[6]

[Total 10]

*This question was generally not answered well, with a surprising number of candidates suggesting in part (i) that 10,000 years of historical data should be obtained. Many answers lacked detail about the sources of data that could be used to generate the event set. In part (iii), many candidates tried to explain what may be wrong with the module, instead of describing the investigations that could be carried out.*

7 (i) Suitable factors are those that would:

affect the likelihood of a claim;  
affect the size of a claim;  
be easily measured, or categorised and ranked.

Extent of standard car security/ease of theft.

Extent of standard car safety measures to prevent accidents, such as Autonomous Emergency Braking and parking sensors.

New Car value/purchase cost/list price.

Cost of replacement parts.

Type of construction/body shell material/bumpers.

Vehicle size/weight/no of seats/number of doors.

Ease of repair/time to repair.

Performance/top speed/acceleration rate/engine size.

Fuel type/transmission type/ 2-wheel vs 4 wheel drive.

Paint finish/trim level/modifications.

[4]

(ii) Advantages

More accurate: if they have lots of data, using their own classification will help them to refine the rates charged,

...to make the groupings more applicable to their own portfolio

...and cover types of vehicle that are excluded from the industry classification.

More control over changes, so may be able to synchronise rate changes more easily

...and keep the classifications more up to date.

Allows a potentially greater understanding of what drives the risk and claims trends

e.g. petrol vs diesel, 5-door vs 3-door, effect of top speed, 4WD vs. other, etc.

Gives a competitive advantage and enables them to make higher profits.

Disadvantages

May not be possible unless they have a large quantity of relevant and recent data.

For brand new make/models, would need to decide how to treat them itself rather than using an industry view.

This might mean that the firm may need to make an assumption, decline business or use an “other” category.

More time-consuming and expensive:

It might take so long to do the groupings that they lose their competitive advantage as the other insurers get their rates out quicker.

They might not have the expertise or relevant computer software in-house.

Can't directly compare or benchmark their data with industry association's because the groupings are different.

May contain mistakes leading to inaccurate classification and rating.

If incorrect, prices more out of line with market, leading to anti-selection or loss of business.

Using own classification may not fit with broker rating engines/question sets.

[6]

[Total 10]

*Better candidates tailored their answer to part (i), as opposed to just listing factors, whereas a significant minority focussed predominantly upon factors relating to vehicle performance. A surprising number of candidates suggested rating factors that do not relate to the classification of motor vehicles, but that may be used in generating an insurance premium. Those who tailored their answer to part (ii) often scored highly.*

**8** The excess level has varied over time, which has not been allowed for.

To allow for the variation in excess, the analyst should estimate the claims that would have been incurred, had the excess been the same level as for year 8.

The excess for years 5 and 6 was higher than it will be in year 8, so there may be some claims missing below the excess point.

Ideally, estimate the missing amounts and add to the total claims amount for these years.

Judging by the excess and claim amounts, the claims are not from the ground up.

It may be easier to make the above adjustments for excess levels if the data could be adjusted so that the claims are from the ground up.

Exposure has changed dramatically from year 5 onwards.

There might have been significant changes to the level of risk as a result of this.

Could weight experience by amount of exposure in each year.

The policy terms and conditions (or cover level, apart from SI and excess) may have changed over the years, or may be changing in year 8.

The analyst should get the underwriter's views on what adjustments may be needed to earlier years.

The earlier years might even not be relevant enough to include in the analysis at all.

We are not told exactly when the analysis is taking place but if it is before the end of year 7, there might be retrospective adjustments to exposure and claims that are not in the figures.

Claims development for recent years is uncertain.

The overall rate could give a lower weight to very recent years to compensate for this.

Use different factors for different sized claims.

Claims development factors may have insufficient allowance for IBNR and IBNER and insufficient allowance for unexpired risk.

If not, the estimate of ultimate claims for recent years may be significantly understated...

...particularly since the analysis is done by underwriting year.

Use case estimates rather than just paid claims.

There is no allowance for monetary inflation of sum insured and claims.

Particularly necessary if inflation for the two is different.

Inflation indices should be used to adjust these values.

There is no allowance for trends in claims experience.

Claims should be adjusted to be as if they arose from the contract year being priced.

This requires a claims trend index (which might be built into the claims inflation index).

Analysis of claims by accident year might help to identify inaccuracies in the development pattern and trends in claims experience.

There is no allowance for unusually heavy or light claims experience.

Some years have no claims so special consideration needs to be given to this, e.g. in the case of IBNR development

The large claims amount in year 2 has a large impact on the average rate.

It could be truncated and only a proportion used in the calculation of the average.  
...or spread over the underwriting years,

There might be some exposure to large claims in the more recent years that has not materialised yet.

The analyst should consider using a catastrophe model to ensure that there is enough allowance for very large claims.

We don't know where the development factors come from, how they were derived, or whether they are appropriate for this book of business.

Knowing how they were derived will help us to assess their appropriateness. (Ideally, we should get the information / triangles used to derive them to check this.)

Other changes over time not taken into consideration such as:

- claims handling procedures
- strictness of underwriting
- the nature of the risk, e.g. improved fire safety measures in the insured building(s).

If the risk has changed significantly, the use of a benchmark, or pricing based on a similar risk may be better than using past data from this risk or use credibility weighting.

[11]

*The responses to this question were mixed. Better candidates tailored their answers to refer to specific features of the data, and used these to suggest improvements. Candidates who provided more generic answers often failed to score well.*

**9** (i) Advantages

It allows an insurer to accept risks that could lead to large claims.

It reduces the risk of insolvency from a catastrophe, a large claim or an aggregation of claims.

It stabilises the technical results of the insurer by reducing claim fluctuations.

It helps make more efficient use of capital by reducing the variance of the claim payments.

Disadvantages

It cedes profit,

i.e. the insurer pays a premium to the reinsurer that in the long run, if priced accurately, will be greater than the expected recoveries under the treaty.

Reinsurer may default.

It is difficult for the ceding insurer to determine how much it should pay for the reinsurance.

[2]

- (ii) It is a form of non-proportional reinsurance/excess of loss reinsurance.

Covers the accumulated losses from one or more risks

above an excess point

subject to an upper limit  
sustained from a single event or from a defined peril(s), or for a class of business

over a defined period, usually one year.

It is often bought in layers from several reinsurers.

The excess and limits may be index-linked through a stability clause.

A limited number of reinstatements may be available, for which there may be a reinstatement premium.

Brokerage fees will normally apply.

[3]

- (iii) Whether the losses provided are from the ground up,

and if not, what the total losses were.

Whether losses provided are uncapped (ideally need limit if not).

Specifics for each loss, such as peril, date of loss, location, number of claims.

The level of exposure (SI, EML or premium written), or at least the extent to which it has changed.

Changes in the limits over time.

If claims are not from the ground up then an ILF table will be required.



Any changes in the claims environment which may account for some of the changes observed to date and in the future.

Whether the losses are finalised or paid plus outstanding.

The extent to which IBNR and IBNER has been allowed for.

The retention and excess (current and historical);

...which may vary by peril, or act in aggregate.

The operation of reinstatements (current and historical).

Other elements of coverage (hours clause, regions, exclusions...)

and how these have changed over time.

What the claims inflation has been over time.

What share the syndicate has in the risks it insures,  
and whether the losses shown are the total loss or its proportion.

Other suggestions:

- Premium charged last year
- Underwriting expertise/strength of syndicate
- Expenses
- Retrocession cost
- Profit or cost of capital load
- Underwriting cycle and competition in the market
- Environmental /climate change considerations
- Brokerage/commission
- Dates on cover
- Contingencies
- Investment return/discounting of claims payments over time

Results of alternative methods for comparison (e.g. output from a cat model)

If premium is used as the exposure measure then rate change information will be required

[7]

[Total 12]

*Part (i) was generally well answered, with many candidates scoring full marks. In part (ii), many candidates provided a general description of excess of loss reinsurance, instead of focussing upon aggregate excess of loss. Some candidates struggled with part (iii), however those who tailored their answer to the detail in the question tended to score well.*

- 10 (i) Note that the observed values,  $\mathbf{y}$ , are from the question, i.e.:

$$\begin{pmatrix} 0.34 \\ 0.63 \\ 0.15 \\ 0.70 \end{pmatrix}$$

$$\mathbf{X} = \begin{pmatrix} 1 & 1 & 0 \\ 1 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \end{pmatrix} \quad \boldsymbol{\beta} = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{pmatrix}$$

- (a) Beta: see above  
 (b) X: see above  
 (c) Column 1 is the base level  
 Column 2 means “is young?”  
 Column 3 means “Is dog?”  
 (note that other orders are equally valid)

[4]

- (ii) Total error,

$$l^* = (34\% - \beta_0 - \beta_1)^2 + (63\% - \beta_0 - \beta_1 - \beta_2)^2 + (15\% - \beta_0)^2 + (70\% - \beta_0 - \beta_2)^2$$

$$(1) \quad \frac{\partial l^*}{\partial \beta_0} = 0 = -2(34\% - \beta_0 - \beta_1) - 2(63\% - \beta_0 - \beta_1 - \beta_2) - 2(15\% - \beta_0) - 2(70\% - \beta_0 - \beta_2)$$

$$(2) \quad \frac{\partial l^*}{\partial \beta_1} = 0 = -2(34\% - \beta_0 - \beta_1) - 2(63\% - \beta_0 - \beta_1 - \beta_2)$$

$$(3) \quad \frac{\partial l^*}{\partial \beta_2} = 0 = -2(63\% - \beta_0 - \beta_1 - \beta_2) - 2(70\% - \beta_0 - \beta_2)$$

Simplifying (2):  $34\% - \beta_0 - \beta_1 = \beta_0 + \beta_1 + \beta_2 - 63\%$

$$(4) \quad \therefore \beta_2 = 97\% - 2\beta_0 - 2\beta_1$$

Simplifying (3):  $63\% - \beta_0 - \beta_1 - \beta_2 = \beta_0 + \beta_2 - 70\%$

$$(5) \quad \therefore 2\beta_2 = 133\% - 2\beta_0 - \beta_1$$

Substituting (4) into (5):  $133\% - 2\beta_0 - \beta_1 = 194\% - 4\beta_0 - 4\beta_1$   
 $\therefore 2\beta_0 + 3\beta_1 = 194\% - 133\%$

(6)  $\therefore 2\beta_0 = 61\% - 3\beta_1$

Substituting (6) into (5):  $2\beta_2 = 133\% - 61\% + 3\beta_1 - \beta_1$

(7)  $\therefore \beta_2 = 36\% + \beta_1$

Simplifying (1):  $8\beta_0 + 4\beta_1 + 4\beta_2 = 364\%$

(8)  $\therefore 2\beta_0 + \beta_1 + \beta_2 = 91\%$

Substituting (7) into (8):  $2\beta_0 + \beta_1 + 36\% + \beta_1 = 91\%$

(9)  $\therefore 2\beta_0 + 2\beta_1 = 55\%$

Substituting (6) into (9):  $61\% - 3\beta_1 + 2\beta_1 = 55\%$

(10)  $\therefore \beta_1 = 6\%$

Substituting (10) into (7):  $\therefore \beta_2 = 36\% + 6\% = 42\%$

Substituting (10) into (6):  $\therefore \beta_0 = \frac{61\% - 3 \times 6\%}{2} = 21.5\%$

$$\therefore \boldsymbol{\beta} = \begin{pmatrix} 21.5\% \\ 6\% \\ 42\% \end{pmatrix}$$

$$\therefore E[Y] = \begin{pmatrix} 21.5\% + 6\% \\ 21.5\% + 6\% + 42\% \\ 21.5\% \\ 21.5\% + 42\% \end{pmatrix} = \begin{pmatrix} 27.5\% \\ 69.5\% \\ 21.5\% \\ 63.5\% \end{pmatrix}$$

### Alternative approach

A solution of the form  $\boldsymbol{\beta} = (\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T \mathbf{y}$  is also acceptable for full marks, as follows.

The estimate of the beta values that minimises the sum of squared errors is  $(\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T \mathbf{y}$

$$\mathbf{X}^T \mathbf{X} = \begin{pmatrix} 4 & 2 & 2 \\ 2 & 2 & 1 \\ 2 & 1 & 2 \end{pmatrix}$$

$$\text{Matrix inverse of } \mathbf{X}^T \mathbf{X} = \begin{pmatrix} 0.75 & -0.5 & -0.5 \\ -0.5 & 1 & 0 \\ -0.5 & 0 & 1 \end{pmatrix}$$

*Candidates could find the inverse by using determinants, or more simply by using elementary row operations (the Gauss-Jordan method).*

$$(\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T = \begin{pmatrix} 0.25 & -0.25 & 0.75 & 0.25 \\ 0.5 & 0.5 & -0.5 & -0.5 \\ -0.5 & 0.5 & -0.5 & 0.5 \end{pmatrix}$$

$$(\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T \mathbf{y} = \begin{pmatrix} 0.215 \\ 0.060 \\ 0.420 \end{pmatrix}$$

[8]

[Total 12]

*Part (i) was generally answered well. Despite a similar example being shown in the core reading, relatively few candidates attempted part (ii), however those who did were generally rewarded well.*

- 11** (i) The report might form part of the company's governance (or risk management) process.

May be a regulatory requirement.

A major risk to the insurer is that the premiums charged do not reflect the risks being insured.

It is used as an early warning indicator as part of the actuarial control cycle

- signalling that the model(s) may no longer be fit for purpose
- and therefore that the premiums being charged are too high/low
- a poor rating structure may highlight anti-selection issues
- and/or that claims trends are changing
- which may inform future reserve projections
- and monitoring of the claims handling function.

May detect possible fraud activity.

May detect underperforming segments, such as distribution channels.

May detect underperforming peril model.

May help to support commercial negotiations over terms of business, such as commissions.

May be used to validate model assumptions.

Helps the company to understand the nature of claims and models, so make better decisions.

[4]

- (ii) The model predicts an average (and possibly a normal range), whereas claims will deviate from this over the short term through randomness.

Certain perils will have low numbers of claims – increasing volatility of frequency.

Certain perils have high volatility in claims amounts (fire, bodily injury). The prediction from the model might not be adjusted for seasonal variation (e.g. freeze).

Some perils are catastrophic in nature and claims occur in clusters (e.g. flood, storm)

- and certain catastrophes are susceptible to demand surge which is unlikely to have been modelled.

Can sometimes get very large claims that distort the analysis.  
The observed may not include IBNR or IBNER, whereas the models are based on fully developed claims.

- or if they do, the projections to ultimate may not be totally reliable if development patterns have changed.

The model may be wrong or not fit for purpose for a variety of reasons:

- the model is out of date
- the model was built on incomplete or inaccurate data
- insufficient interactions
- the rating factors used by the insurer for the product do not allow a highly predictive model to be built
- ...e.g. if constrained by legislation
- the insurer has introduced new rating factors which are not in the models
- business is being written through channels or in areas where the insurer has no previous experience
- exclusion or addition of cover
- change in compulsory excess
- changes in other terms and conditions
- incorrect error structure/link function/offset
- errors when simplifying factors, e.g. when grouping levels of a factor or fitting curves
- poor choice of base period for GLM, e.g. unusually light experience

errors in grouping data, e.g. errors in grouping postcodes using spatial smoothing

Changes in the external and internal claims environment e.g.:

Claims handling processes may have changed, resulting in different experience.

Claims inflation may be different from that expected and allowed for in the models (if any).

Changes in claims behaviour due to external environment e.g. recession / road safety campaigns leading to changing frequency/severity trends

Changes in legislation such as limits on the size of claim payments.

Changes in the exchange rate if the insurer has overseas risks.

Data errors in recording of claims

...particularly where claims handling is outsourced

...or where there is a mixture of data systems involved.

Unexpected mix or sales channel, which influences claims

e.g. more business from price comparison websites (or other suitable example).

[10]

[Total 14]

*Most candidates offered a considerable number of points for part (i). In part (ii), stronger candidates applied their knowledge of standard bookwork to the example given, generating a wide range of different ideas.*

## **END OF EXAMINERS' REPORT**