CM1 NOVEMBER 2019

SOLUTION

Q1:

An income protection health insurance contract pays an income to the policyholder while he/she is SICK.

with the definition of sickness being carefully specified in the policy conditions

If the policyholder recovers, the cover under the policy usually continues, so that subsequent bouts of qualifying sickness would merit further benefit payments.

Such policies are usually subject to a deferred period (eg 3 months) of continuous sickness that has to have elapsed before any benefits start to be paid, and during which no benefit is payable.

Premiums for these policies would normally be regular (eg monthly) and would typically be waived during periods of qualifying sickness. This means that premiums would not be paid at the same time as benefits are payable.

Q2:

The key steps in a data analysis process can be described as follows:

1. **Develop a well-defined set of objectives which need to be met by the results of the data analysis.**

The objective may be to summarise the claims from a sickness insurance product by age, gender and cause of claim, or to predict the outcome of the next national parliamentary election.

1. **Identify the data items required for the analysis.**

1. **Collection of the data from appropriate sources**.

The relevant data may be available internally (eg from an insurance company’s administration department) or may need to be gathered from external sources (eg from a local council office or government statistical service).

1. **Processing and formatting data for analysis, eg inputting into a spreadsheet, database or other model.**
2. **Cleaning data, eg addressing unusual, missing or inconsistent values.**

**Q3:**

(1) 5|17:40

this expression represents the probability of two lives to live for first five years then one of the 2 lives to die until next 17 years, given second is still alive.

(2) constant force of mortality (mu)= 0.01 (given)

evaluating the given expression :

5|17:40

= 5p40:40 \* 17:45

now since lives are independent and identical,

= 0.5 \* 5p40:40 \* 17:45

* 0.5 \* 5p40:40 \* (1-17:45)
* 0.5 \* 5p40:40 \* (1 –  17p45:45 )
* 0.5 \* 5p40 \* 5p40 \* (1 –  17p45 \*17p45 )
* 0.5 \* \* (1 – )
* 0.5 \* \* (1 - )

Answer =0.1304005

Q4:

The term big data is not well defined but has come to be used to describe data with characteristics that make it impossible to apply traditional methods of analysis (for example, those which rely on a single, well-structured data set which can be manipulated and analysed on a single computer). Typically, this means automatically collected data with characteristics that have to be inferred from the data itself rather than known in advance from the design of an experiment.

Given the description above, the properties that can lead data to be classified as ‘big’ include:

size, not only does big data include a very large number of individual cases, but• each might include very many variables, a high proportion of which might have empty (or null) values – leading to sparse data;

speed, the data to be analysed might be arriving in real time at a very fast rate – for• example, from an array of sensors taking measurements thousands of time every second;

variety, big data is often composed of elements from many different sources which• could have very different structures – or is often largely unstructured;

reliability, given the above three characteristics we can see that the reliability of• individual data elements might be difficult to ascertain and could vary over time (for example, an internet connected sensor could go offline for a period).

Examples of ‘big data’ are:

the information held by large online retailers on items viewed, purchased and• recommended by each of its customers

measurements of atmospheric pressure from sensors monitored by a national• meteorological organisation

the data held by an insurance company received from the personal activity trackers (that• monitor daily exercise, food intake and sleep, for example) of its policyholders.

Although the four points above (size, speed, variety, reliability) have been presented in the context of big data, they are characteristics that should be considered for any data source. For example, an actuary may need to decide if it is advisable to increase the volume of data available for a given investigation by combining an internal data set with data available externally. In this case, the extra processing complexity required to handle a variety of data, plus any issues of reliability of the external data, will need to be considered.

Q5:

(1)

(a)

Equation of value at time 0: P \* a(due)\_x = 1\*

(B) prospective reserve at time t:

TVX^P = 1\* - P \* a(due)x + t

(c)

Retrospective reserve at time t:

TVX^R = (P \* a(due)x: <t> - 1\*)

(2)

Assuming equal basis:

P =

* AX  = a(due)x \* P
* A x^1:<t> + t|AX = (a(due) x:<t> + t|aduex)\*P
* A x^1:<t> + t|AX = P \* a(due) x:<t> + t| aduex \* P
* A x^1:<t> + tpx\*(v^t)\*Ax+t = P \* a(due) x:<t> + tpx\*(v^t)\*aduex+t \*P
* A x^1:<t> - P \* a(due) x:<t> = tpx\*(v^t)\*aduex+t \*P - tpx\*(v^t)\*Ax+t
* A x^1:<t> - P \* a(due) x:<t> = tpx\*(v^t)\*( aduex+t \*P - Ax+t)
* {(A x^1:<t> - P \* a(due) x:<t>)\*(1+i)^t}/tpx = aduex+t \*P - Ax+t
* TVX^R = TVX^P

Hence proved

Q6:

1. Forward rates given:

|  |  |  |  |
| --- | --- | --- | --- |
| f0,1 | f 1,1 | f2,1 | f3,1 |
| 4% | 5% | 6% | 7% |

First we need to find the spot rates:

Denoted by y

y1 = (1+0.04)^-1=0.96154

y2 = 1/1.04\*1.05=0.91575

y3 = 1/1.04\*1.05\*1.06 = 0.86392

y4 = 1/1.04\*1.05\*1.06\*1.07 = 0.807398

now, since security is redeemable at par and issues coupons @4 per annum in arrears

price = (0.04\*0.96154)+(0.04\*0.91575)+(0.04\*0.86392)+(0.04\*0.807398) + 1\*(0.80739)

* Price= 0.9493242

Therefore for 100 nominal , the investor has to pay 94.932.

Now, for gross redemption yield

Price = 0.04\*a<4> + 1\*(1+i)^(-4)

* 0.94932 = 0.04\* + 1\*(1+i)^(-4)

using table modes of calculator:

WE WILL GET i = 5.444%

(2)

Since gross redemption yield is the weighted average of all the spot rates, we can see that the gross redemption yield is lower

Than the f3,1 = 7%

As it is the last term of the interest structure.

And we can see that the gross redemption yield is in between all the spot rates.

Q7:

Initial sum assured = 20000

We are given a whole life increasing assurance increased by 2000 pa

There fore EPV(benefits) = 18000\*A45  + 2000\* (IA)45

EPV(benefits) = 18000\*0.276050 + 2000\* 8.33628 (from tables)

EPV(benefits)=21641.46

Now, premiums are payable annually in advance for a maximum of 20 years or till death,

Therefore premium(P)= EPV(benefits)/adue45:20

* P = 21641.46/13.780479
* P = 1570.443

Now, we need reserve at the end of 2018th year

Means t = 17

17V45(PROSPECTIVE)= EPV(benefits) - EPV(premiums)

17V45(PROSPECTIVE) = (20000+2000\*16)\*A62 + 2000\*(IA)62 – 1570.443 \* adue62:<3>

17V45(PROSPECTIVE) = 52000\*0.48458+2000\*8.20491 - 1570.443\*2.85664

17V45(PROSPECTIVE) = 37121.78971

Now, death strain = sum assured(s) - 17V45

Sum assured at the end of 17th year is 52000

Therefore death strain = 52000-37121.78971

Death strain = 14878.21029

Now, mortality profit is given by expected death strain – actual death strain

expected death strain = 378 \* q61 \* (death strain=14878.21029)

expected death strain= 50666.28708

actual death strain = 4\*14878.21029

actual death strain= 59512.84116

therefore mortality profit= 50666.28708-59512.84116

= - 8846.55408

Since actual death strain is higher than expected death strain, insurance company would incure a mortality loss of 8846.55408

(2)

The actual deaths are 4 in comparison to the expected death that is 378\*0.009009= 3.4

Thats why there is loss.

Q8:

Nominal value= 1000000

Coupons= 90000 pa payable half yearly

Redeemed at 10% profit= 1100000

Income tax = 15%

We need to calculate the price the invester must pay to ensure a net effective yield of at least 8% pa

Now, since we have two options of time to redeem,

We must consider the worst case scenario for the investor,

in which the loan must be redeemed as late as possible:

therefore we will take the term to be 25 years

now,

price(P)= (90000-13500)\* + 1100000\*(1.08)^-25

P = 76500\*10.8842 + 1100000\*1.08^-25

P = 993260.9951

(2)

Price paid by second investor who purchased the loan exactly after 10 years

Now, income tax = 25%

Capital gains tax = 35%

Price(P) = (90000-13500)\* + (1100000)\*(1.08)^-15

P = 1014410 (THIS IS THE PRICE THAT SECOND INVESTOR WILL PAY TO THE FIRST IF THE FIRST INVESTOR SELLS HIS LOAN TO HIM EARNING 8% EFFECTIVE YIELD)

(3)

PRICE(P) = (90000-22500)\* + (1100000)\*(1+i)^(-15) – (1100000-P)\*0.35\*(1+i)^-15

Using table mode of the calculator,

We will find i = 7.0%

Q9

Equation of value:

EPV PREMIUMS = EPV BENEFITS

SINCE THERE IS A SINGLE PREMIUM,

EPV OF PREMIUMS WILL BE THE VALUE TO SINGLE PREMIUM PAID AT STARTING ONLY,

NOW, EPV OF BENEFITS HAVE 2 PARTS:

BENEFITS OF MAN: 250 + (20000+10\*12)(a(12)<5> + 5|a(12)65)

BENEFITS OF WOMEN: (10000+10\*12)((1.04)^(-5)\*5q60­\*5p58\*a(12)63 + (1.04)^(-5)\*5p60­\*5p58\*a(12)65|63)

NOW ,

a(12)<5>  = a<5> \* 0.04/0.039285

a(12)<5> = 4.4518 \* 0.04/0.039285

a(12)<5> = 4.532824

5|a(12)65 = (1.04)^(-5)\*(9647.797/9826.131) \* ( a­65 + 11/24)

5|a(12)65 = (1.04)^(-5)\*(9647.797/9826.131) \* ( 12.6656 + 11/24)

5|a(12)65 = 10.5911848

a(12)63 = a63  + 11/24

a(12)63 = 14.606114 + 11/24

a(12)63 = 15.06444733

a(12)65|63 = a(12)63 - a(12)65:63

a(12)65|63 = 15.06444733 – (a65:63  + 11/24)

a(12)65|63 = 3.323713

putting in values

EPV OF BENEFITS= 250 + (20000+10\*12)( 4.532824 + 10.5911848)

+ (10000+10\*12)((1.04)^(-5)\*5q60­\*5p58\*15.06444733 + (1.04)^(-5)\*5p60­\*5p58\*3.323713)

EPV OF BENEFITS = EPV OF PREMIUMS = VALUE OF SINGLE PREMIUM = 333657.8

Q10 (PAYEMENT STREAM INTEGRATION QUESTION)

(1)

ACCUMULATED VALUE AT T = 6

= 10\*

= 10\*

= 14.0495

Present value t=0

= +

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