Subject CS2

Corrections to 2021 study material

0 Introduction

This document contains details of any errors and ambiguities that have been brought to our attention in the Subject CS2 study materials for the 2021 exams. We will incorporate these changes into the study material each year. We are always happy to receive feedback from students, particularly details concerning any errors, contradictions or unclear statements in the courses. If you have any such comments on this course please email them to CS2@bpp.com.

You may also find it useful to refer to the Subject CS2 threads on the ActEd Discussion Forum. (You can reach the Forums by clicking on the 'Discussion Forums' button at the top of the ActEd homepage, or by going to **www.acted.co.uk/forums/**.)

This document was last updated on **9 November 2021**.

1 Paper A Course Notes

Chapter 15

Page 14 ***(added on 1 March 2021)***

The R code to create the `qpareto()` function uses the incorrect character for a minus sign in two places (meaning it won't run when copied into R). It should be:

```
qpareto <- function(p,a,lambda){
  lambda * ((1-p)^(-1/a)-1)
}
```

Chapter 18

Page 11 ***(added on 25 June 2021)***

The distribution in the question on this page is the three-parameter Pareto distribution, not the generalised Pareto distribution. The question should read:

Claims from a particular portfolio have a three-parameter Pareto distribution with parameters $\alpha = 6$, $\lambda = 200$ and $k = 4$. A proportional reinsurance arrangement is in force with a retained proportion of 80%.

Calculate the mean and variance of the amount paid by the insurer and the reinsurer in respect of a single claim.

Chapter 19

Page 15 ***(added on 1 April 2021)***

The equation near the bottom of the page showing that $\left.\frac{d^3}{dt^3}\log M_S(t)\right|_{t=0}$ is equal to λm_3 is incorrect. It should be:

$$\left.\frac{d^3}{dt^3}\log M_S(t)\right|_{t=0} = \lambda\left[\frac{d^3}{dt^3}\left(M_X(t)-1\right)\right]_{t=0} = \lambda m_3$$

Chapter 21

Page 37 ***(added on 25 June 2021)***

The following sentence below the first Core Reading paragraph is incorrect and should not be there:

Here B_1 corresponds to the *vector* of covariates $(x_{11}, x_{21}, \ldots, x_{J1})$ for the first individual.

2 Assignments

Assignment X1 Solutions

Question 3 ***(added on 9 November 2021)***

The solution for Chain 1 does not reflect the latest Core Reading on periodicity. The solution should read:

Chain 1 is not periodic or aperiodic. It is not possible to return to State 1 at all and State 2 is aperiodic.

Assignment Y1 Solutions

Question 1 ***(added on 15 December 2020)***

The solutions to part (iii) are incorrect.

Part (iii)(a)

For part (iii)(a), the solutions incorrectly give the three-step transition probability from level 3+ to level 1 instead of the three-step transition probability from level 4+ to level 1.

After calculating the three-step transition probability matrix, the solution should read:

So the probability is 0.0478. [1]

We can also extract the probability using indexing:

```
      P3[5,1]
[1] 0.047785
      P3["level 4+", "level 1"]
[1] 0.047785
```

At the end of the solution, the alternative using the `markovchain` object should read:

```
      (mc^3)@transitionMatrix[5,1]
[1] 0.047785
```

Part (iii)(b)

For part (iii)(b), the solutions sum probabilities from the wrong row of the five-step transition probability matrix. After calculating the five-step transition probability matrix, the solution should read:

Having a discount of 15% or less means being on level 1, 2, 3+ or 3-. For a driver currently on level 5, the probability of this being the case in 5 years' time is the sum of the first four numbers on the last row of P5.

Calculating this in R:

```
sum(P5[7, 1:4]) #
```

[1]

```
[1] 0.1489257
```

So the probability is 14.89%. [1]

[Total 5]

Alternatively, using the matrix power function:

```
sum(Pn(P, 5)[7, 1:4])
```

```
[1] 0.1489257
```

As another alternative, using the markovchain object:

```
sum((mc^5)@transitionMatrix[7, 1:4])
```

```
[1] 0.1489257
```

Question 3 ***(added on 14 April 2021)***

Part (iv)

The cox model fitted in part (iv) does not use Breslow's approximation for ties. The solution should read:

```
cox.fit = coxph(surv.obj ~ surv.data$status, ties = "breslow")
summary(cox.fit)
```

```
Call:
coxph(formula = surv.obj ~ surv.data$status, ties = "breslow")

  n= 200, number of events= 150

                     coef exp(coef) se(coef)      z Pr(>|z|)
surv.data$statusT -1.1028    0.3319   0.1874 -5.886 3.96e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

                  exp(coef) exp(-coef) lower .95 upper .95
surv.data$statusT    0.3319      3.013    0.2299    0.4792

Concordance= 0.633  (se = 0.02 )
Likelihood ratio test= 35.34  on 1 df,   p=3e-09
Wald test            = 34.64  on 1 df,   p=4e-09
Score (logrank) test = 37.69  on 1 df,   p=8e-10
```

So, we estimate β to be –1.1028.

Part (v)

The stated value of $e^{\hat{\beta}}$ should instead be 0.3319. The stated p-value should instead be 3.96×10^{-9}. These are in line with the corrected output shown for part (iv).

Part (vii)

Using the updated value of $\hat{\beta}$, the probability for part (a) should be:

```
      exp(-integrate(h1, 0, 40)$value)
[1] 0.950294
```

The probability for part (b) should be:

```
      exp(-integrate(h0, 0, 40)$value)
[1] 0.857615
```

Parts (vi) and (vii)

These parts are not significantly affected by the updated value of $\hat{\beta}$. The graphical output is very similar and the same commentary still applies.

Assignment Y2 Solutions

Question 1 ***(added on 1 April 2021)***

There is a mistake in the alternative R code provided at the end of the paragraph under the definition of the `fMLE` function. The minus sign should go outside the `log` function. It should read:

This function uses the `dweibull` command, which gives the probability density function of the Weibull distribution. This is easier than writing the log-likelihood function ourselves. We have taken logs by setting `log=TRUE`. (If we had used the default `log=FALSE`, we would have had to use `sum(-log(dweibull…).)`

3 PBOR

Chapter 7 Solutions

Pages 8 and 9 ***(added on 14 April 2021)***

In Q7.2(iv)(c), the plot of the integrated hazard should start at 0 and go up to time 25, the time when the last life was censored. The final code after incorporating the adjusting the y-axis limits should be:

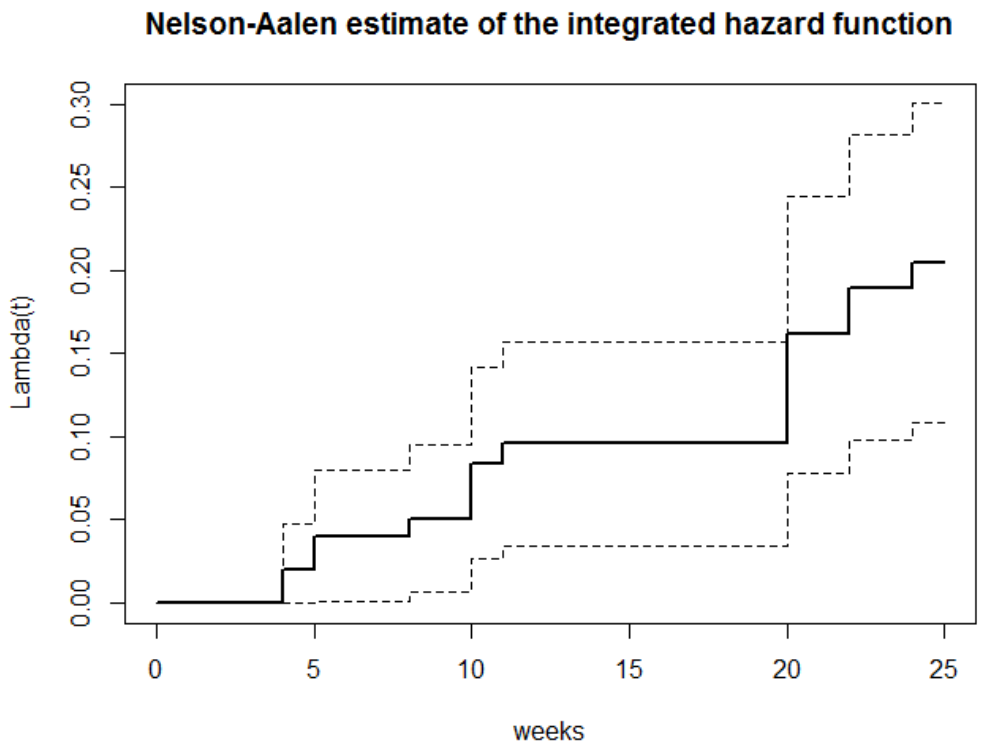
```
end.time = surv.data$Time[nrow(surv.data)]
end.i.haz = deaths$Lj[length(deaths$Lj)]

plot(c(0, deaths$tj, end.time),
     c(0, deaths$Lj, end.i.haz),
     type = "s", lwd = 2,
     main = "Nelson-Aalen estimate of the integrated hazard
function",
     xlab = "weeks",
     ylab = "Lambda(t)",
     ylim = c(0, 0.3))

end.lower = Lj.CI$lower[length(Lj.CI$lower)]
end.upper = Lj.CI$upper[length(Lj.CI$upper)]

lines(c(0, deaths$tj, end.time),
      c(0, Lj.CI$lower, end.lower), type = "s", lty = 2)

lines(c(0, deaths$tj, end.time),
      c(0, Lj.CI$upper, end.upper), type = "s", lty = 2)
```



Page 11 ***(added on 14 April 2021)***

In Q7.2(v)(c) the y-axis label should be `SNA(t)` instead of `SKM(t)` as it is a plot of the Nelson-Aalen estimate. The code should be:

```
plot(fitna,
main = "Nelson-Aalen estimate of survival function",
xlab = "weeks",
ylab = "SNA(t)", ylim = c(0.6, 1))
```

Pages 12 and 13 ***(added on 14 April 2021)***

In Q7.2(vi)(b) the y-axis label should be `S(t)` instead of `SKM(t)` as it is a plot of both estimates (initially the Nelson-Aalen estimate is plotted and then the Kaplan-Meier estimate is subsequently added to the plot). The `plot()` function code should be:

```
plot(fitna,
     main = "Nelson-Aalen estimate of survival function",
     xlab = "weeks",
     ylab = "S(t)", ylim = c(0.7, 1))
```

Chapter 8 Solutions

Page 5 ***(added on 16 September 2021)***

The value of the partial log-likelihood for the new model stated in the penultimate paragraph is incorrect. This paragraph should read:

The partial log-likelihood of the new model is the higher value, here the –73.61374. The test statistic is:

Chapter 11

Page 3 ***(added on 9 February 2021)***

The `for` loop in the code on page 3 has an error in the calculation of `Phixj`. The final term should be added instead of subtracted. In this particular case, this makes no difference to the final output.

The code should be:

```
for(x in xvalues){
      term = a0 + a1*x;
      for(j in 1:(n-2)){
      c1 = (xx[n] - xx[j])/(xx[n] - xx[n-1])
      c2 = (xx[n-1] - xx[j])/(xx[n] - xx[n-1])
      Phixj = phi(x,j) - c1*phi(x,n-1) + c2*phi(x,n)
      term=term+b[j]*Phixj}
yvalues = c(yvalues,term)
}
```

The formula for $\Phi_j(x)$ given near the bottom of page 3 also contains the same error. The formula should be:

$$\Phi_j(x) = \phi_j(x) - \left(\frac{x_n - x_j}{x_n - x_{n-1}}\right)\phi_{n-1}(x) + \left(\frac{x_{n-1} - x_j}{x_n - x_{n-1}}\right)\phi_n(x)$$

Page 7 ***(added on 9 February 2021)***

The same error occurs when this code is repeated at the bottom of page 7. The preceding text and code should read:

The variable `Phixj` corresponds to $\Phi_j(x)$, which is calculated by subtracting the adjustment term $c_1\phi_{n-1}(x)$ and adding the adjustment term $c_2\,\phi_n(x)$, where $c_1 = \dfrac{x_n - x_j}{x_n - x_{n-1}}$ and $c_2 = \dfrac{x_{n-1} - x_j}{x_n - x_{n-1}}$, from the value of $\phi_j(x)$.

```
for(j in 1:(n-2)){
      c1 = (xx[n] - xx[j])/(xx[n] - xx[n-1])
      c2 = (xx[n-1] - xx[j])/(xx[n] - xx[n-1])
      Phixj = phi(x,j) - c1*phi(x,n-1) + c2*phi(x,n)
      term = term + b[j]*Phixj}
```

4 Revision Notes

Booklet 3

Page 153 ***(added on 6 July 2021)***

The final Kolmogorov forward equation is incorrect as it should not have a minus sign. It should be:

$$\frac{d}{dt}P_{20}(t) = 0.2P_{21}(t)$$

5 Additional Mock Pack

Mock 2 Questions

Question 7 ***(added on 16 September 2021)***

The equation for $\hat{k}_t$ just above part (iv) uses the wrong year. It should read:

$$\hat{k}_t = -0.59 - 0.03(t - 2019) \text{ for } t > 2019$$

Mock 2 Solutions

Page 29 ***(added on 6 July 2021)***

The final sentence above the box incorrectly refers to the integral part as I, rather than X. It should read:

The integral part, X, of both of the above equations is the same. So:

$$p_{10}(t) = \frac{3}{5} \times 8 \times p_{01}(t) = 4.8 \times p_{01}(t)$$

6 ASET

April 2017 – Solutions

Page 24 ***(added on 9 August 2021)***

The calculations shown for the moments of the normal approximation just under the first box incorrectly use 25 instead of 80 as the value of n. It should read:

The $Binomial\left(80,\frac{1}{2}\right)$ distribution can be approximated using a normal distribution with the same mean and variance, *ie* $N\left(80\times\frac{1}{2},80\times\frac{1}{2}\times\frac{1}{2}\right)\equiv N\left(40,20\right)$.

7 Mini-ASET

April 2021 – Paper A solutions

Page 15 ***(added on 9 November 2021)***

Some of the forces of mortality in the calculations for Town B have the wrong subscripts (A instead of B). The solution should read:

Then substituting $\hat{\mu}_B^S = 1.5\hat{\mu}_B^{NS}$:

$$= 0.2\left(1.5\hat{\mu}_B^{NS}\right) + 0.8\hat{\mu}_B^{NS}$$

$$= 1.1\hat{\mu}_B^{NS}$$

Solving we get:

$$\hat{\mu}_B^{NS} = \frac{0.0151}{1.1} = 0.01373$$

$$\hat{\mu}_B^S = 1.5\hat{\mu}_B^{NS} = 0.02059$$

April 2021 – Paper B Solutions

Page 22 ***(added on 16 September 2021)***

The second sentence in the lightbulb box references the wrong question part. It should say:

The test statistic for the interaction term is the difference between the likelihood ratio test statistics output for the models in parts (vi) and (viii), ie 910.2 – 820.3 = 89.9, which is highly significant under the chi-squared distribution with one degree of freedom.

8 Paper A Handouts

Day 5 Solutions

Page 42 ***(added on 9 November 2021)***

The second paragraph in part (iii) is missing athlete 10. It should read:

For the first split point, athletes 5, 10, 12, 15 and 16 are taller than 195cm. These athletes all play basketball and have been classified correctly.