Dept of Mathematics and Statistics
King Fahd University of Petroleum & Minerals

AS475: Survival Models for Actuaries
Dr. Mohammad H. Omar
Major 3 Exam Term 132 FORM A
Wednesday May 7 2014
4.30pm-6.00pm

Name_____ ID#:_____ Serial #:___

Instructions.

1. Please turn off your cell phones and place them under your chair. Any student caught with mobile phones on during the exam will be considered under the **cheating rules** of the University.
2. If you need to leave the room, please do so quietly so not to disturb others taking the test. No two person can leave the room at the same time. No extra time will be provided for the time missed outside the classroom.
3. Only materials provided by the instructor can be present on the table during the exam.
4. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.
5. Use the blank portions of each page for your work. Extra blank pages can be provided if necessary. If you use an extra page, indicate clearly what problem you are working on.
6. Only answers supported by work will be considered. Unsupported guesses will not be graded.
7. While every attempt is made to avoid defective questions, sometimes they do occur. In the rare event that you believe a question is defective, the instructor cannot give you any guidance beyond these instructions.
8. Mobile calculators, I-pad, or communicable devices are disallowed. Use regular scientific calculators or financail calculators only. Write important steps to arrive at the solution of the following problems.

The test is 90 minutes, GOOD LUCK, and you may begin now!

Question	Total Marks	Marks Obtained	Comments
1	2+4+5=11		
2	2+5+4=11		
3	4+4=8		
4	6		
5	3+6=9		
6	1+4=5		
Total	50		

Extra blank page

1. (2+4+5=11 points) Consider an alternative approach to controlling for Sex using an extended Cox model. Define an interaction term between sex and time that allows for diverging survival curves over time.

a) For the situation just described, write down the extended Cox model, which contains Rx, $\log WBC$, and Sex as main effects plus the product term $Sex \times time$.

b) Using the model described in (a) above, express the hazard ratio for the effect of Sex adjusted for Rx and $\log WBC$ at 8 and 16 weeks.

c) The following results are obtain for part (a)

Time Dependent Cox Regression Analysis

Analysis time $\_t$: survt	Coef.	Std Err	$p > \|z\|$	Haz.Ratio	[95%	Conf. Intrvl]
Sex	1.820	1.012	0.072	6.174	0.849	44.896
$\log WBC$	1.464	0.336	0.000	4.322	2.236	8.351
Rx	1.093	0.479	0.022	2.984	1.167	7.626
Sex x time	-0.345	0.199	0.083	0.708	0.479	1.046
No. of Subjects = 42			Log likelihood = -70.416			

Describe the hazard ratio estimate for the treatment effect adjusted for the other variables in the model, and **summarize the results of the significance test** and **interval estimate** for this hazard ratio.

2. (2+5+4=11 points) A log-logistic AFT model is fitted using the data from Veteran's Administration Lung Cancer Trial. The exposure of interest is treatment status TX (standard = 1, test = 2). The control variables are *performance status* ($PERF$), *disease duration* (DD), AGE, and *prior therapy* ($PRIORTX$). These predictors are used in the section on frailty models. The outcome is *time* to death (in days). The output is shown below.

Log-logistic regression - accelerated failure time form

LR chi2(5) = 61.31
Log likelihood = −200.196 Prob > chi2 = 0.0000

_t	**Coef.**	**Std Err**	z	$p > \|z\|$
tx	-0.054087	0.1863349	-0.29	0.772
perf	0.0401825	0.0046188	8.70	0.000
dd	0.0042271	0.0095831	0.44	0.659
age	0.0086776	0.0092693	0.94	0.349
priortx	0.0032806	0.0225789	0.15	0.884
_cons	1.347464	0.6964462	1.93	0.053
/ln_gam	-0.4831864	0.0743015	-6.50	0.000
gamma	0.6168149	0.0458303		

a) State the AFT log-logistic model in terms of $S(t)$ (note: gamma = $1/p$).

b) Estimate the acceleration factor γ with a 95% confidence interval comparing the test and standard treatment ($TX = 2$ vs. $TX = 1$). Interpret your answer.

c) The AFT log-logistic model is also a proportional odds model. Use the output to estimate the odds ratio (odds of death) comparing the test and standard treatment. Also estimate the survival odds ratio comparing the test and standard treatment.

3. (4+4=8 points) A Weilbull model was run with the "addicts" dataset. The predictor of interest is $CLINIC$ (coded 1 or 2) for two methadone clinics for heroin addicts. Covariates include $DOSE$ (continuous) for methadone dose (mg/day), $PRISON$ (coded 1 if patient has a prison record and 0 if not), and a prison-dose product term (called $PRISDOSE$). The outcome is *time* (in days) until the person dropped out of the clinic or was censored.

The Weilbull survival and hazard functions are, respectively, $S(t) = \exp(-\lambda t^p)$ and $h(t) = \lambda p t^{p-1}$

where $\lambda^{1/p} = \exp[-(\alpha_0 + \alpha_1 CLINIC + \alpha_2 PRISON + \alpha_3 DOSE + \alpha_4 PRISDOSE)]$ for the AFT parameterization and $\lambda = \exp[\beta_0 + \beta_1 CLINIC + \beta_2 PRISON + \beta_3 DOSE + \beta_4 PRISDOSE]$ for the PH parameterization.

The Stata output for both the AFT and PH forms of the model are presented as follows:

Weilbull regression
accelerated failure-time form
Log likelihood = −260.74854

_t	**Coef.**	**Std Err**	z	$p > \|z\|$
clinic	0.698	0.158	4.42	0.000
prison	0.145	0.558	0.26	0.795
dose	0.027	0.006	4.60	0.000
prisdose	-0.006	0.009	-0.69	0.492
_cons	3.977	0.376	10.58	0.000
/In_p	0.315	0.068	4.67	0.000
p	1.370467			
1/p	0.729678			

Weilbull regression
log relative-hazard form
Log likelihood = −260.74854

_t	**Coef.**	**Std Err**	z	$p > \|z\|$
clinic	-0.957	0.213	-4.49	0.000
prison	-0.198	0.765	-0.26	0.795
dose	-0.037	0.008	-4.63	0.000
prisdose	0.009	0.013	0.69	0.491
_cons	-5.450	0.702	-7.76	0.000
/In.p	0.315	0.068	4.67	0.000
p	1.370467			
1/p	0.729678			

a) Estimate the acceleration factor with a 95% confidence interval comparing $CLINIC = 2$ vs $CLINIC = 1$. Interpret this result.

b) Use the output to estimate the **median survival time** for a patient from $CLINIC = 2$ who has a prison record and receives a methadone dose of 50 mg/day. (Hint: use the relationship that $t = [\text{In } S(t)]^{1/p} \times \left(1/\lambda^{1/p}\right)$ for a Weilbull model)

4. (6 points). Suppose that Allie (A), Sally (S) and Callie (C) are the only three subjects in the dataset shown below. All three subjects have two recurrent events that occur at different times.

ID	**Status**	**Stratum**	**Start**	**Stop**	**tx**
A	1	1	0	70	1
A	1	2	70	90	1
S	1	1	0	20	0
S	1	2	20	30	0
C	1	1	0	10	1
C	1	2	10	40	1

Fill in the following data layout below describing survival (in weeks) to **the first event (stratum 1)**. (Recall that m_f and q_f denote the number of failures and censored observations at time $t_{(f)}$. The survival probabilities in the last column use the KM product limit formula).

$t_{(f)}$	n_f	m_f	q_f	$R(t_{(f)})$	$S_1(t_{(f)})$
0	3	0	0	{A,S,C}	1.00
10					

Work Shown (4 points):

5. (3+6=9 points) Use **percentile matching** to estimate (with smoothed empirical estimates) parameters for the exponential and Pareto distributions for the *workers compensation on medical payments* data (KPW Data Set B) below.

27	82	115	126	155	161	243	294	340	384
457	680	855	877	974	1193	1340	1884	2558	15743

a) For the exponential distribution, use the 50th percentile.

b) For the Pareto distribution, use the 30th and 80th percentiles .

6. (4+1=5 points) You are given the following:

- The random claim size variable X (in thousands) has the density function

$$f(x) = \alpha x^{\alpha-1}, \qquad 0 < x < \infty, \quad \alpha > 1.$$

- A random sample of three observations of X yields the values 0.40, 0.70, 0.90 .

Determine the value of $\tilde{\alpha}$, the method of moments estimator of α.

a) $\tilde{\alpha} < 0.5$
b) $0.5 \leq \tilde{\alpha} < 1.5$
c) $1.5 \leq \tilde{\alpha} < 2.5$
d) $2.5 \leq \tilde{\alpha} < 3.5$
e) $\tilde{\alpha} \geq 3.5$
Work shown (4 points).

So the answer is ( )

END OF TEST PAPER

Chi-square table added here

Building :6Room :103
Date: From:7-5-2014 To:7-5-2014
Days:w
Start Time:4:00 PM End Time:6:30 PM
Term:201320
The above room(s) has been reserved for you.
Please update your records accordingly.
Thank You
Dr. Ahmad A. Al-Dharrab
University Registrar
King Fahd University of Petroleum & Minerals