

Homework 9

STA4322/STA5328

Introduction to Statistics Theory

Spring 2020, MWF 3:00pm

Due date: Friday, April 17th, 2020 at 5:00pm

All work must be shown for complete credit. W.M.S. denotes the course textbook, *Mathematical Statistics with Applications*. [Problem 3c](#) is worth 1pt of extra credit.

1. Suppose that Y_1, \dots, Y_n denote a random sample from the probability density function given by

$$f_Y(y | \theta, \lambda) = \begin{cases} \left(\frac{1}{\theta}\right) e^{-\frac{(y-\lambda)}{\theta}} & y > \lambda \\ 0 & \text{otherwise} \end{cases}$$

- (a) Find the likelihood ratio test statistic for testing $H_0 : \theta = \theta_0$ versus $H_A : \theta > \theta_0$ with λ unknown.
- (b) Assuming n is sufficiently large and the “regularity conditions” are satisfied, use Wilk’s theorem to find the rejection region of an asymptotic level α test for the hypotheses in (a).
- (c) Find the likelihood ratio test for testing $H_0 : \lambda = \lambda_0$ versus $H_A : \lambda > \lambda_0$ with θ unknown.
2. Suppose that X_1, \dots, X_n are independent and identically distributed exponential random variables with mean β_X and Y_1, \dots, Y_n are independent and identically distributed with mean β_Y . Recall that this the density for an exponentially distributed random variable U with mean β ,

$$f_U(u) = \frac{1}{\beta} e^{-\frac{u}{\beta}} \mathbf{1}(u > 0).$$

We wish to test the hypotheses

$$H_0 : \beta_X = \beta_Y, \quad \text{vs} \quad H_A : \beta_X \neq \beta_Y.$$

Let $\Theta = (\beta_X, \beta_Y)$. Let $L(x, y | \Theta)$ be the joint likelihood of $X_1, \dots, X_n, Y_1, \dots, Y_n$ evaluated at Θ .

- (a) What is $\max_{\Theta \in \Omega_0} L(x, y | \Theta)$?
- (b) What is $\max_{\Theta \in \Omega_0 \cup \Omega_A} L(x, y | \Theta)$?
- (c) Show that the likelihood ratio test rejects H_0 if

$$\frac{(\sum_{i=1}^n X_i)(\sum_{i=1}^n Y_i)}{[\sum_{i=1}^n (X_i + Y_i)]^2} < k.$$

No need to find k , you must only show that the rejection region has the form above.

3. A random sample W_1, \dots, W_n is drawn from a distribution with density

$$f_W(w) = \frac{\theta \nu^\theta}{w^{\theta+1}} 1(w \geq \nu)$$

where $\theta > 0$ and $\nu > 0$ are unknown parameters.

- (a) Find the MLE of θ and ν .
- (b) Give the likelihood ratio test statistic λ .
- (c) (Extra credit) Show that the LRT for

$$H_0 : \theta = 1, \nu > 0 \quad \text{vs} \quad H_A : \theta \neq 1, \nu > 0$$

has rejection region of the form

$$\{X : T(X) \leq c_1 \cup T(X) \geq c_2\}$$

where $0 < c_1 < c_2$ are some constants (no need to find them) and

$$T(X) = \log \left[\frac{\prod_{i=1}^n W_i}{(W_{(1)})^n} \right],$$

where $W_{(1)} = \min(W_1, \dots, W_n)$.