

# Rejection Regions and P - Values

At the  $\alpha \in (0, 1)$  significance level, using the test statistic  $TT$ , with observed value  $TT_0 = TT(\theta = \theta_0)$ , to test

$$H_0 : \theta = \theta_0, \text{ versus}$$

**a.**  $H_1 : \theta < \theta_0$  (left-tailed test):

$$RR = (-\infty, tt_\alpha), \quad P = P(TT < TT_0).$$

**b.**  $H_1 : \theta > \theta_0$  (right-tailed test):

$$RR = (tt_{1-\alpha}, \infty), \quad P = P(TT > TT_0).$$

**c.**  $H_1 : \theta \neq \theta_0$  (two-tailed test):

$$RR = (-\infty, tt_{\frac{\alpha}{2}}) \cup (tt_{1-\frac{\alpha}{2}}, \infty), \quad P = 2 \min\{P(TT < TT_0), P(TT > TT_0)\} \left( \stackrel{\text{sym}}{=} 2P(TT > |TT_0|) \right).$$

**1.** For a population mean,  $\theta = \mu$ ,

– large sample ( $n > 30$ ) or normal underlying population and  $\sigma$  known,  $TT = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}} \in N(0, 1)$ ;

– large sample ( $n > 30$ ) or normal underlying population  $TT = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}} \in T(n - 1)$ .

**2.** For a population variance,  $\theta = \sigma^2$ , for a normal underlying population,  $TT = \frac{(n - 1)s^2}{\sigma^2} \in \chi^2(n - 1)$ .

**3.** For the difference of two population means,  $\theta = \mu_1 - \mu_2$ , for large samples ( $n_1 + n_2 > 40$ ) or normal underlying populations and independent samples,

–  $\sigma_1, \sigma_2$  known,  $TT = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \in N(0, 1)$ ;

–  $\sigma_1 = \sigma_2$ , unknown,  $TT = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \in T(n_1 + n_2 - 2)$ , where  $s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$ ;

–  $\sigma_1 \neq \sigma_2$ , unknown,  $TT = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \in T(n)$ , with

$$\frac{1}{n} = \frac{c^2}{n_1 - 1} + \frac{(1 - c)^2}{n_2 - 1} \quad \text{and} \quad c = \frac{\frac{s_1^2}{n_1}}{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}.$$

**4.** For the ratio of two population variances,  $\theta = \frac{\sigma_1^2}{\sigma_2^2}$ , for normal underlying populations and independent

samples,  $TT = \frac{s_1^2/\sigma_1^2}{s_2^2/\sigma_2^2} \in F(n_1 - 1, n_2 - 1)$ .