

STAT 111

Recitation 7

Mo Huang

Email: mohuang@wharton.upenn.edu

Office Hours: Wednesdays 3:00 - 4:00 pm, JMHH F96

Slides (adapted from Gemma Moran): github.com/mohuangx/STAT111-Fall2018

October 26, 2018

Estimation Summary

- ▶ Binomial parameter θ :

Estimate: p

95% confidence interval: $p \pm \sqrt{1/n}$

- ▶ Mean μ :

Estimate: \bar{x}

95% confidence interval: $\bar{x} \pm 2 \frac{s}{\sqrt{n}}$

- ▶ Difference between proportions $\theta_1 - \theta_2$:

Estimate: $p_1 - p_2$

95% confidence interval: $p_1 - p_2 \pm \sqrt{\frac{1}{n} + \frac{1}{m}}$

- ▶ Difference between means $\mu_1 - \mu_2$:

Estimate: $\bar{x}_1 - \bar{x}_2$

95% confidence interval: $\bar{x}_1 - \bar{x}_2 \pm 2 \sqrt{\frac{s_1^2}{n} + \frac{s_2^2}{m}}$

Note:

$$s = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_n^2 - n(\bar{x}^2)}{n-1}}.$$

Linear Regression

- ▶ How does the growth height of a plant in a greenhouse depend on the amount of water that we give it?
- ▶ Let x be the amount of water we plan to give the plant (fixed).
- ▶ Let Y be the (future) growth height of a plant (random variable).
- ▶ **Linear Regression Model:** for the i th observation,
 - ▶ Mean of $Y_i = \alpha + \beta x_i$, Variance of $Y_i = \sigma^2$.

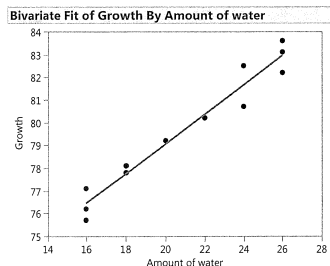


Figure: Data: $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$

Linear Regression

- Mean of $Y_i = \alpha + \beta x_i$, Variance of $Y_i = \sigma^2$. How do we estimate α , β ?

Calculate: $s_{xx} = x_1^2 + x_2^2 + \cdots + x_n^2 - n(\bar{x}^2) = \sum_{i=1}^n x_i^2 - n(\bar{x}^2)$

$$s_{yy} = y_1^2 + y_2^2 + \cdots + y_n^2 - n(\bar{y}^2) = \sum_{i=1}^n y_i^2 - n(\bar{y}^2)$$

$$s_{xy} = x_1 y_1 + x_2 y_2 + \cdots + x_n y_n - n(\bar{x}\bar{y}) = \sum_{i=1}^n x_i y_i - n(\bar{x}\bar{y}).$$

- Estimate β by b and α by a :

$$b = s_{xy}/s_{xx}$$

$$a = \bar{y} - b\bar{x}$$

- Estimate σ^2 by s_r^2 :

$$s_r^2 = (s_{yy} - b^2 s_{xx})/(n - 2).$$

- How accurate is the estimate b of β ?

$$\text{Standard deviation of } b : \frac{s_r}{\sqrt{s_{xx}}} \Rightarrow 95\% \text{ C.I. } b \pm 2 \frac{s_r}{\sqrt{s_{xx}}}$$

Example

Plant number	1	2	3	4	5	6	7	8	9	10	11	12
Amount of water	16	16	16	18	18	20	22	24	24	26	26	26
Growth height	76.2	77.1	75.7	78.1	77.8	79.2	80.2	82.5	80.7	83.1	82.2	83.6

► $\bar{x} = 21, \bar{y} = 79.7, s_{xx} = 188, s_{yy} = 83.54, s_{xy} = 122.4$

► Estimate α, β

$$b = s_{xy}/s_{xx} = 0.6511$$

$$a = \bar{y} - \beta\bar{x} = 79.7 - (0.6511)(21) = 66.03$$

► Estimate σ^2

$$s_r^2 = \frac{83.54 - (0.6511)^2(188)}{10} = 0.3850$$

► Find a 95% C.I. for β .

$$95\% \text{ C.I. for } b : 0.6511 \pm 2 \frac{\sqrt{0.3850}}{\sqrt{188}} \Rightarrow (0.56, 0.74)$$