# Lecture Note 1: Parameters and Estimators

Population parameters: properties of <u>random variables</u>

$$X, \mu_X, \sigma_X^2 \qquad \beta\,\theta$$

↑ central tendency

↖ dispersion

Statistics: properties of <u>samples</u>

Sample: N observations of $X$: $x_1, x_2, \cdots, x_N$

"iid" → independent and identically distributed

Estimators are statistics that approximate parameters

Greek letters for parameters: $\mu, \sigma^2, \beta, \theta$

Hats for estimators: $\hat{\mu}, \hat{\sigma}^2, \hat{\beta}, \hat{\theta}$

Desirable properties for $\hat{\theta}$:

① Unbiasedness: $E[\hat{\theta}] = \theta$

② Consistency: as $N \to \infty$, $Pr[|\hat{\theta} - \theta| > \varepsilon] \to 0$ for any $\varepsilon > 0$

$$\hat{\theta} \xrightarrow{p} \theta$$

③ Efficiency: $\hat{\theta}$ has smallest possible $V[\hat{\theta}]$

$\hat{\theta}$ has a distribution!

"Variance"

$$V[X] \to \text{std. dev. of } X = \sqrt{V[X]}$$

$$V[\hat{\theta}] \to \text{std. error of } \hat{\theta} = \sqrt{V[\hat{\theta}]}$$