

## 程序代写代做 CS编程辅导



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# ECON3206 Financial Econometrics

## Week-1: A Review of Random Variables and Distributions



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May 20, 2020

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## Random Variables: Definitions

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- RV and probability distribution

- Two types of RV

- Discrete RV: it takes a countable number of values.
- Continuous RV: it takes any value in a interval.

- Probability distribution (how likely the values occur)

- Discrete RV

- Probability mass (pmf):

$X$	$x_1$	$x_2$	$x_3$	...
$P(X = x_i)$	$p_1$	$p_2$	$p_3$	...

- Cumulative distribution function (cdf):  $P(X \leq x) = \sum_{x_i \leq x} p_i$

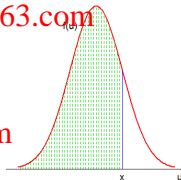
- Continuous RV

- Probability density (pdf):  $f(u)$

- Cumulative distribution (cdf):

$$F(x) = P(X \leq x) = \int_{-\infty}^x f(u) du$$

Area under  $f(u)$  curve up to  $x$



## Random Variables: Unconditional (marginal) Expectations (moments)

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## • Characterise RVs

## – Mean or expected value

- The weighted average of all possible values, a measure of location

- Discrete RV:  $E(X) = \sum_i x_i P(X = x_i)$

- Continuous RV:  $E(X) = \int_{-\infty}^{\infty} u f(u) du$

– Mean of  $g(X)$  (e.g.  $X^2$  or  $e^{aX}$ )

- Discrete RV:  $E[g(X)] = \sum_i g(x_i) P(X = x_i)$

- Continuous RV:  $E[g(X)] = \int_{-\infty}^{\infty} g(u) f(u) du$

– Variance of  $X$ :

- A measure of the amount of variation in all possible values

$$\text{Var}(X) = E\{[X - E(X)]^2\} = E(X^2) - [E(X)]^2$$

– Covariance between  $X$  and  $Y$ 

- A measure of association

$$\text{Cov}(X, Y) = E\{[X - E(X)][Y - E(Y)]\}$$



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## Random Variables: Conditioning

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- Conditional distribution of  $Y$  given  $X$
- The distribution of  $Y$  when  $X$  is “known”.
  - It depends on  $X$ .
  - It is denoted as  $Y|X$ .



eg. the distribution of  $wage$  for  $age = 20$ ,  
the distribution of  $wage$  for  $age = 30$ ,  
 $wage|age$  depends on  $age$ .

$bhp_t | bhp_{t-1}$ :  
dist. of  $bhp_t$   
when  $bhp_{t-1}$  is  
“fixed”

- Conditional expectation  $E[Y|X]$
- It is calculated with the conditional distribution, treating  $X$  as “known” or “fixed”.
  - It depends on  $X$  and, hence, is also a RV.

## Random Variables

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– Conditional mean  $E(Y|X)$ 

- $E(Y|X)$  generally depends on  $X$ .

eg. Linear regression  $Y = a + bX + \varepsilon$ .

$$E(Y|X) = a + bX + E(\varepsilon|X) = a + bX.$$

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– Conditional variance of  $Y$  given  $X$ 

- $\text{Var}(Y|X)$  generally depends on  $X$ .

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eg. Linear regression  $Y = a + bX + \varepsilon$ .

$$\text{Var}(Y|X) = \text{Var}(\varepsilon|X)$$

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## Properties of Expectation operator

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Let  $X$  and  $Y$  be RV and  $a$  a constant.

- Expectation is a linear operator

$$E(a) = a, \quad \text{Var}(a) = 0$$

$$E(aX) = aE(X);$$

$$E(X + Y) = E(X) + E(Y);$$

$$E[g(X)|X] = g(X) \text{ for any function } g(\cdot);$$

$$E(Y) = E[E(Y|X)] \text{ (Law of total expectations);}$$

$$E(Y|X) = E(Y) \text{ if } Y \text{ is independent of } X;$$

- Variance is a nonlinear operator

$$\text{Var}(aX) = a^2 \text{Var}(X);$$

$$\text{Var}(X + Y) = \text{Var}(X) + \text{Var}(Y) + 2\text{Cov}(X, Y);$$

$$\text{Var}(Y) = E[\text{Var}(Y|X)] + \text{Var}[E(Y|X)].$$



$$E\left(\frac{X}{Y}\right) \neq \frac{E(X)}{E(Y)}$$

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## Sample moments

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– Suppose we have  $n$  (independent and identically distributed) observations

$$\{X_t\}_1^T = \{X_1, X_2, \dots, X_T\}, \quad \{Y_t\}_1^T = \{Y_1, Y_2, \dots, Y_T\}.$$

– Sample mean

$$\bar{X} = \frac{1}{T} \sum_{t=1}^T X_t$$

- a measure of location (central tendency)

- an estimator of population mean  $E(X)$

– Sample variance and standard deviation

$$\hat{\sigma}_X^2 = \frac{1}{T-1} \sum_{t=1}^T (X_t - \bar{X})^2, \quad \hat{\sigma}_X = \sqrt{\hat{\sigma}_X^2}$$

- a measure of variation

- an estimator of the population variance  $\text{Var}(X)$



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## Behold the summation operator

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**Linear operator:**

$$\sum_{t=1}^T (a + bx_t + cy_t) = \sum_{t=1}^T a + b \sum_{t=1}^T x_t + c \sum_{t=1}^T y_t$$

**Summation of a constant:**

$$\sum_{t=1}^T a = Ta$$

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**Nonlinear relations:**

$$\sum_{t=1}^T x_t y_t \neq \sum_{t=1}^T x_t \sum_{t=1}^T y_t \quad \sum_{t=1}^T \frac{x_t}{y_t} \neq \frac{\sum_{t=1}^T x_t}{\sum_{t=1}^T y_t}$$

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