

LECTURE 1

Introduction to Econometrics

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WHAT IS ECONOMETRICS?

To beginning students, it may seem as if econometrics is an overly complex obstacle to an otherwise useful education. (. . .) To professionals in the field, econometrics is a fascinating set of techniques that allows the measurement and analysis of economic phenomena and the prediction of future economic trends.

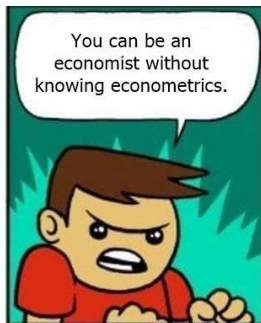
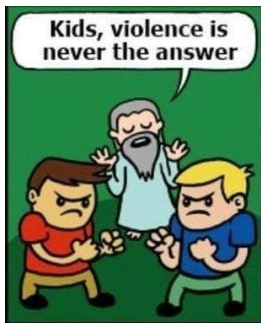
Studenmund (*Using Econometrics: A Practical Guide*)

WHAT IS ECONOMETRICS?

- ❑ Econometrics is a set of statistical tools and techniques for quantitative measurement of actual economic and business phenomena

- ❑ It attempts to
 1. quantify economic reality
 2. bridge the gap between the abstract world of economic theory and the real world of human activity

- ❑ It has three major uses:
 1. describing economic reality
 2. testing hypotheses about economic theory
 3. forecasting future economic activity



EXAMPLE

- Consumer demand for a particular commodity can be thought of as a relationship between
 - quantity demanded (Q)
 - commodity's price (P)
 - price of substitute good (P_s)
 - disposable income (Y)
- Theoretical functional relationship:

$$Q = f(P, P_s, Y)$$

- Econometrics allows us to specify:

$$Q = 31.50 - 0.73P + 0.11P_s + 0.23Y$$

INTRODUCTORY ECONOMETRICS COURSE

- **Lecturer:** Dali Laxton (CERGE-EI, Prague)
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- **Lectures / Seminars:** Friday, 9:00-11:50 room VT 105
- **Office hours:** Saturday by appointment 17:00-18:00

INTRODUCTORY ECONOMETRICS COURSE

• Course requirements:

- 2 quizzes and 2 home assignments (account for 40 points)
- Midterm exam (account for 30 points)
- Final exam/project (account for 30 points)
- to pass the course, student has to get at least 50 points in total

• Recommended literature:

- Studenmund, A. H., *Using Econometrics: A Practical Guide*
- Wooldridge, J. M., *Introductory Econometrics: A Modern Approach*
- Adkins, L., *Using gretl for Principles of Econometrics*

COURSE CONTENT

• Lectures:

- Lecture 1: Introduction, repetition of statistical background, non-technical introduction to regression
- Lectures 2 - 4: Linear regression models
- Lectures 5 - 11: Violations of standard assumptions

• In-class exercises:

- Will serve to clarify and apply concepts presented on lectures
- We will use statistical software to solve the exercises

LECTURE 1.

• Introduction, repetition of statistical background

- probability theory
- statistical inference

• Readings:

- Studenmund, A. H., Using Econometrics: A Practical Guide, Chapter 16
- Wooldridge, J. M., Introductory Econometrics: A Modern Approach, Appendix B and C

RANDOM VARIABLES

- A **random variable** X is a variable whose numerical value is determined by chance. It is a quantification of the outcome of a random phenomenon.
- **Discrete random variable:** has a countable number of possible values
Example: the number of times that a coin will be flipped before a heads is obtained
- **Continuous random variable:** can take on any value in an interval
Example: time until the first goal is scored in a football match between **Liverpool** and Manchester United

DISCRETE RANDOM VARIABLES

- Described by listing the possible values and the associated probability that it takes on each value
- **Probability distribution** of a variable X that can take values x_1, x_2, x_3, \dots :

$$P(X = x_1) = p_1$$

$$P(X = x_2) = p_2$$

$$P(X = x_3) = p_3$$

:

- **Cumulative distribution function (CDF):**

$$F_X(x) = P(X \leq x) = \sum_{i=1, x_i \leq x} P(X = x_i)$$

SIX-SIDED DIE: PROBABILITY DISTRIBUTION FUNCTION

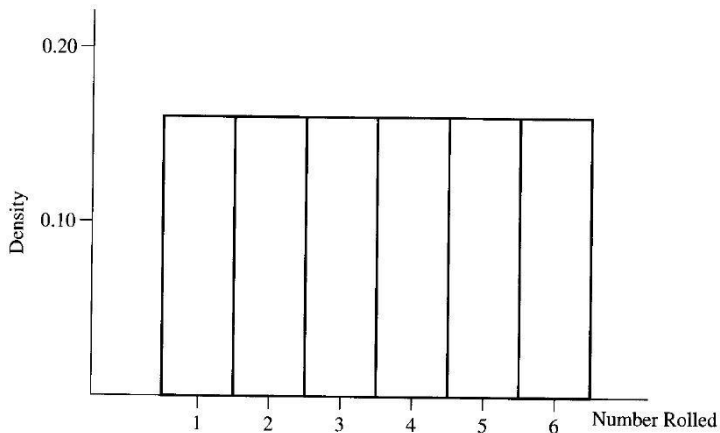
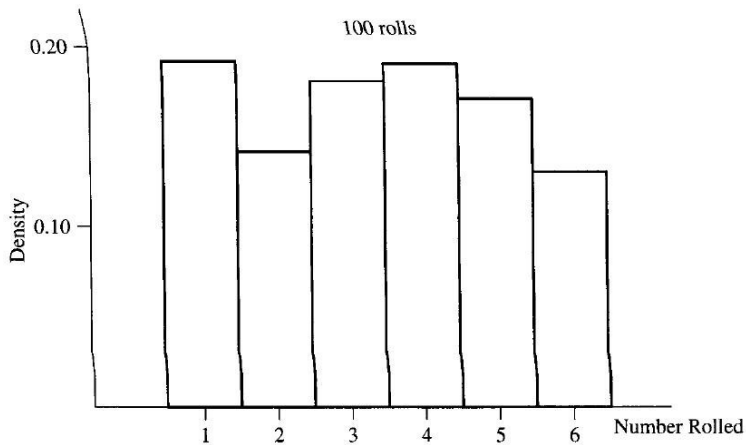
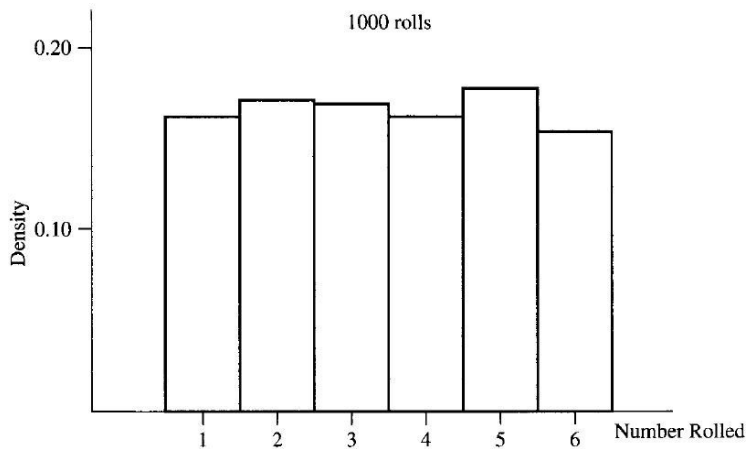


Figure 16.3 Probability Distribution for a Six-Sided Die

SIX-SIDED DIE: HISTOGRAM OF DATA (100 ROLLS)



SIX-SIDED DIE: HISTOGRAM OF DATA (1000 ROLLS)



CONTINUOUS RANDOM VARIABLES

• **Probability density function** $f_X(x)$ (PDF) describes the relative likelihood for the random variable X to take on a particular value x

• **Cumulative distribution function** (CDF):

$$F_X(x) = P(X \leq x) = \int_{-\infty}^x f_X(t) dt$$

• **Computational rule:**

$$P(X > x) = 1 - P(X \leq x)$$

EXPECTED VALUE AND MEDIAN

- **Expected value (mean):**

Mean is the (long-run) average value of random variable

Discrete variable

$$E[X] = \sum_{i=1} x_i P(X = x_i)$$

Continuous variable

$$E[X] = \int_{-\infty}^{+\infty} x f_X(x) dx$$

Example: calculating mean wind speed given wind speed distribution and power curve

- **Median :** "the value in the middle"

EXERCISE 1

- A researcher is analyzing data on financial wealth of 100 professors at a small liberal arts college. The values of their wealth range from \$400 to \$400,000, with a mean of \$40,000, and a median of \$25,000.
- However, when entering these data into a statistical software package, the researcher mistakenly enters \$4,000,000 for the person with \$400,000 wealth.
- How much does this error affect the mean and median?

VARIANCE AND STANDARD DEVIATION

- **Variance:**

Measures the extent to which the values of a random variable are dispersed from the mean.

If values (outcomes) are far away from the mean, variance is high. If they are close to the mean, variance is low.

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

- **Standard deviation :**

$$\sigma_X = \sqrt{\text{Var}[X]}$$

- **Note:** Outliers influence on variance/sd.

DANCING STATISTICS

Watch the video "Dancing statistics: Explaining the statistical concept of variance through dance":

<https://www.youtube.com/watch?v=pGfwj4GrU1A&list=PLEzw67WWDg82xKriFiOoixGpNLXK2GNs9&index=4>

Use the 'dancing' terminology to answer these questions:

1. How do we define variance?
2. How can we tell if variance is large or small?
3. What does it mean to evaluate variance within a set?
4. What does it mean to evaluate variance between sets?
5. What is the homogeneity of variance?
6. What is the heterogeneity of variance?

EXERCISE 2

- Which has a higher expected value and which has a higher standard deviation:
 - a standard six-sided die or
 - a four-sided die with the numbers 1 through 4 printed on the sides?
- Explain your reasoning, without doing any calculations, then verify, doing the calculations.

COVARIANCE, CORRELATION, INDEPENDENCE

• Covariance:

- How, on average, two random variables vary with one another.
- Do the two variables move in the same or opposite direction?
- Measures the amount of linear dependence between two variables.

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

• Correlation:

Similar concept to covariance, but easier to interpret.
It has values between -1 and 1.

$$\text{Corr}(X, Y) = \frac{\text{Cov}(X, Y)}{\sigma_X \sigma_Y}$$

INDEPENDENCE OF VARIABLES

- **Independence** : X and Y are independent if the conditional probability distribution of X given the observed value of Y is the same as if the value of Y had not been observed.
- If X and Y are independent, then $Cov(X, Y) = 0$ (not the other way round in general)
- Dancing statistics: explaining the statistical concept of correlation through dance

<https://www.youtube.com/watch?v=VFjaBh12C6s&index=3&list=PLEzw67WWDg82xKriFiOoixGpNLXK2GNS9>

COMPUTATIONAL RULES

$$E(aX + b) = aE(X) + b$$

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

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

$$\text{Cov}(aX, bY) = \text{Cov}(bY, aX) = ab\text{Cov}(X, Y)$$

$$\text{Cov}(X + Z, Y) = \text{Cov}(X, Y) + \text{Cov}(Z, Y)$$

$$\text{Cov}(X, X) = \text{Var}[X]$$

RANDOM VECTORS

- Sometimes, we deal with vectors of random variables

- Example: $\mathbf{X} = \begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix}$

- Expected value: $E[\mathbf{X}] = \begin{pmatrix} E[X_1] \\ E[X_2] \\ E[X_3] \end{pmatrix}$

- Variance/covariance matrix:

$$\text{Var}[\mathbf{X}] = \begin{pmatrix} \text{Var}[X_1] & \text{Cov}(X_1, X_2) & \text{Cov}(X_1, X_3) \\ \text{Cov}(X_2, X_1) & \text{Var}[X_2] & \text{Cov}(X_2, X_3) \\ \text{Cov}(X_3, X_1) & \text{Cov}(X_3, X_2) & \text{Var}[X_3] \end{pmatrix}$$

STANDARDIZED RANDOM VARIABLES

- Standardization is used for better comparison of different variables
- Define Z to be the standardized variable of X :

$$Z = \frac{X - \mu_X}{\sigma_X}$$

- The standardized variable Z measures how many standard deviations X is below or above its mean
- No matter what are the expected value and variance of X , it always holds that

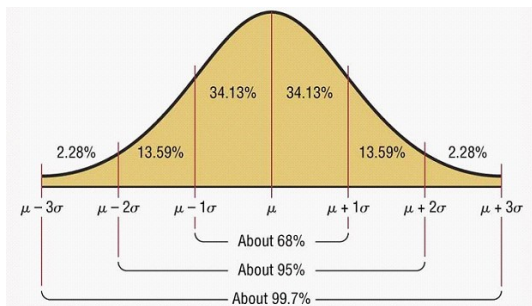
$$E[Z] = 0 \quad \text{and} \quad \text{Var}[Z] = \sigma_Z^2 = 1$$

NORMAL (GAUSSIAN) DISTRIBUTION

• Notation : $X \sim N(\mu, \sigma^2)$

• $E[X] = \mu$

• $Var[X] = \sigma^2$



• Dancingstatistics

<https://www.youtube.com/watch?v=dr1DynUzjq0&index=2&list=PLEzw67WWDg82xKriFiOoixGpNLXK2GNS9>

EXERCISE 3

- The heights of U.S. females between age 25 and 34 are approximately normally distributed with a mean of 66 inches and a standard deviation of 2.5 inches.
- What fraction of U.S. female population in this age bracket is taller than 70 inches, the height of average adult U.S. male of this age?

EXERCISE 4

- A woman wrote to Dear Abby, saying that she had been pregnant for 310 days before giving birth.
- Completed pregnancies are normally distributed with a mean of 266 days and a standard deviation of 16 days.
- Use statistical tables to determine the probability that a completed pregnancy lasts
 -) at least 270 days
 -) at least 310 days

SUMMARY

- Today, we revised some concepts from statistics that we will use throughout our econometrics classes
- It was a very brief overview, serving only for information what students are expected to know already
- The focus was on properties of statistical distributions and on work with normal distribution tables

NEXT LECTURE

- We will go through terminology of sampling and estimation
- We will start with regression analysis and introduce the Ordinary Least Squares estimator